HAZARDOUS
SITE CONTROL
DIVISION

Remedial Planning Field Investigation Team (REM FIT)

ZONE II

CONTRACT NO.
68-01-6692

CH2M HILL
Ecology &
Environment

REMEDIAL INVESTIGATION REPORT

CHARLEVOIX SITE

CHARLEVOIX, MICHIGAN

WA46.5L53.0

[redacted], [redacted]
FEBRUARY 7, 1985

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Chapter 1
INTRODUCTION

This remedial investigation (RI) report for the Charlevoix site in Charlevoix, Michigan, is prepared in partial satisfaction of Contract No. 68-01-6692, Work Assignment No. 46.5L53.0, and the Final Work Plan Tasks 1 through 4.

1.1 BACKGROUND SUMMARY

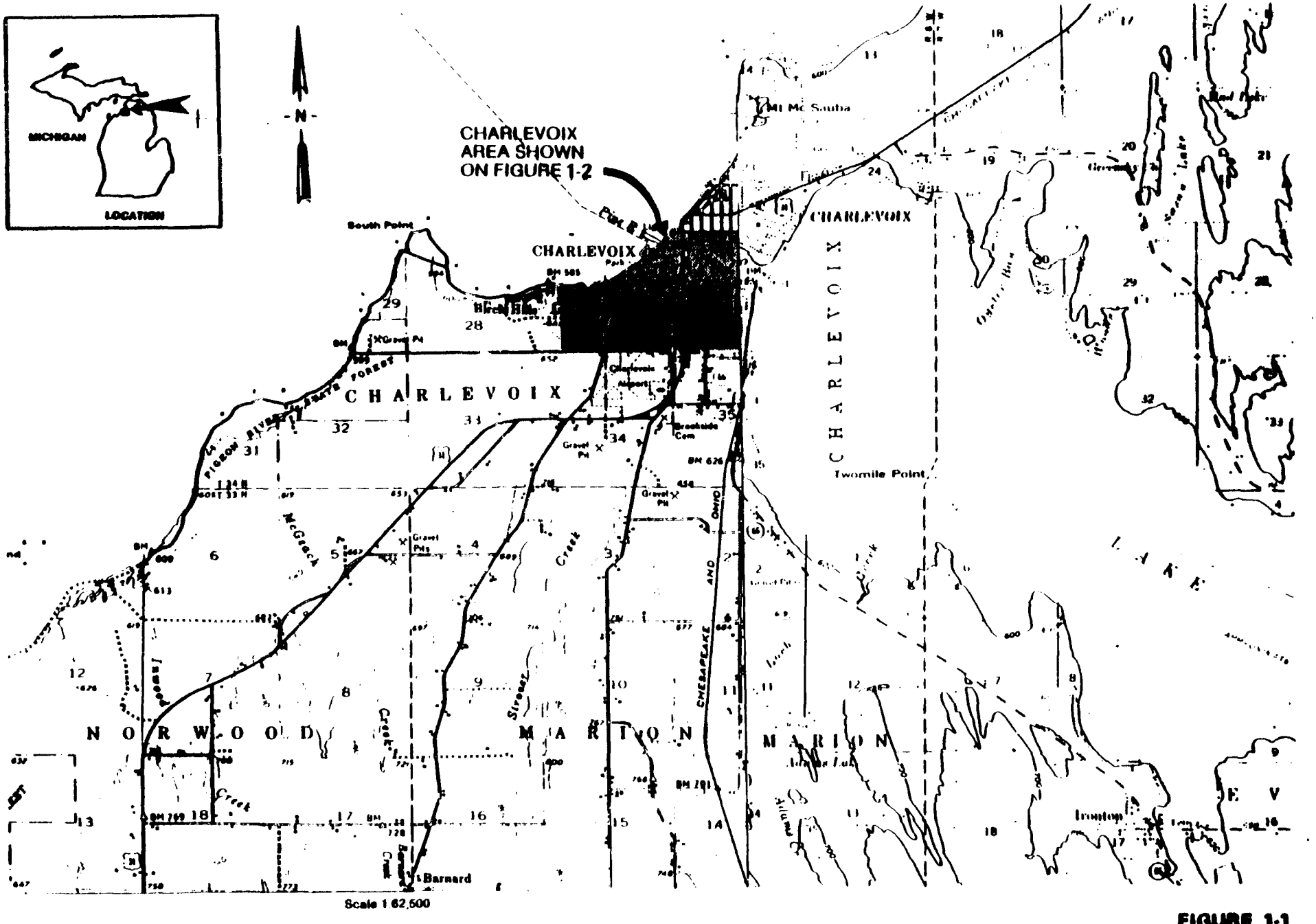
The City of Charlevoix is located in northern Michigan on the shore of Lake Michigan (Figure 1-1).

The year-round population of 3,500 residents and the summer influx of an additional 1,500 part-time residents of Charlevoix are supplied with potable water from a caisson and flume collection system buried in beach deposits 80 feet from the Lake Michigan shoreline (Figure 1-2). Two 225-foot flumes extend from the caisson parallel to the lake shore, receiving water from the groundwater system and from infiltration of Lake Michigan water through the beach sands.

In September 1981, the Michigan Department of Public Health (MDPH) detected trichloroethylene (TCE) ranging in concentrations from 13 ug/L to 30 ug/L in tap water from the Charlevoix water supply system. A monitoring program was begun and continued to detect gradually rising levels of TCE at the well. In December 1982, concentrations of TCE exceeded 100 ug/L at the well. At that point, the city installed an emergency diffused aeration system in the caisson to remove some of the TCE. Based on water quality data, the aeration system is able to remove 30 to 40 percent of TCE. With this diffused aeration system operating, concentrations of TCE in the water supply system have generally been below 50 ug/L.

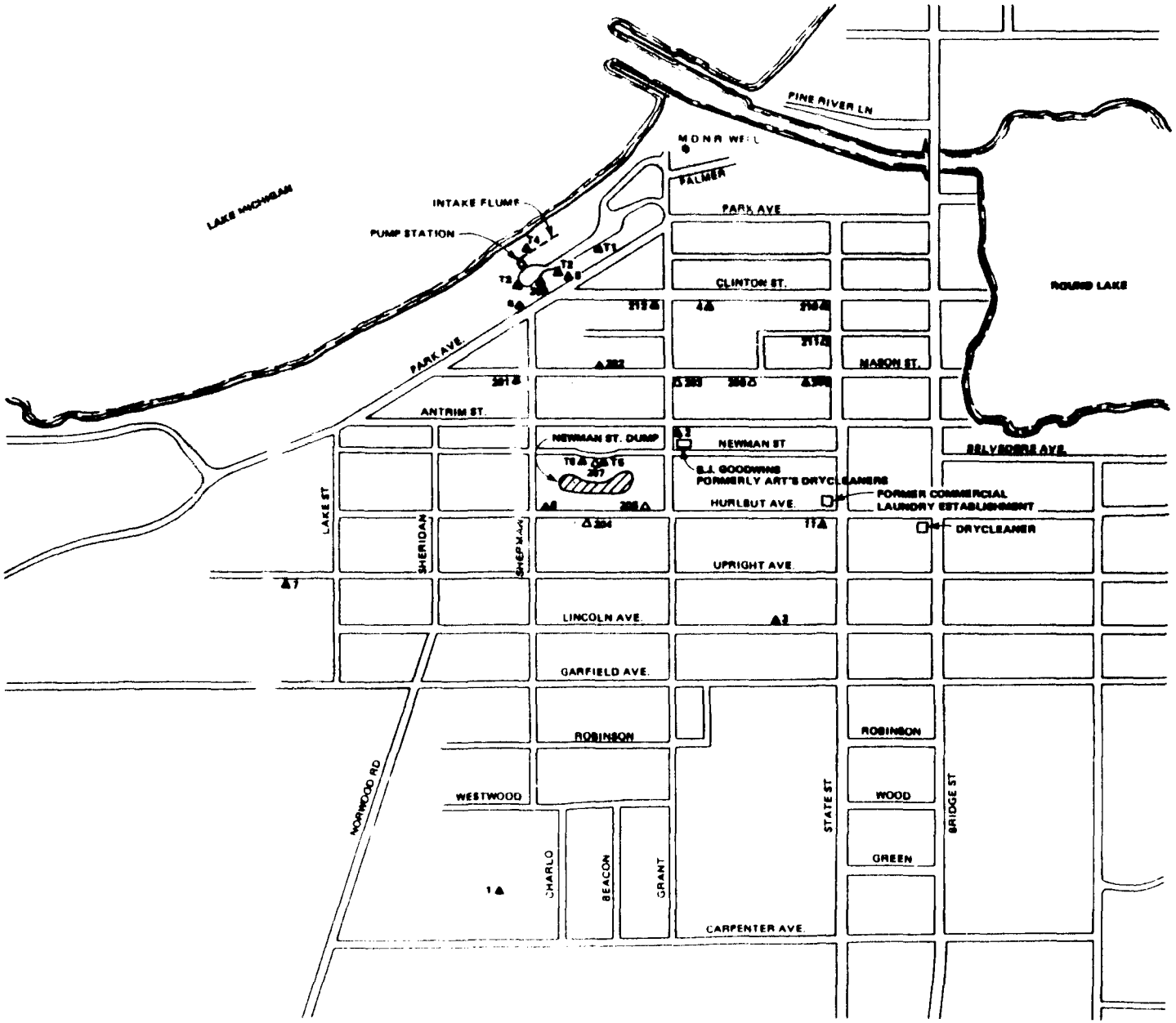
In June and July 1982, the EPA's Technical Assistance Team (TAT) drilled 13 test wells in the vicinity of the water intake structure without locating the source of contamination. Sampling of the test wells found varying concentrations of TCE and perchloroethylene (PCE). Chloroform (85 ug/L) and toluene (1 ug/L) were also identified in one well (T5) upgradient from the flume. No consistent results or identifiable plume for chloroform or toluene were found during the remedial investigations.

TCE and PCE are chlorinated organic compounds that are widely used in various industrial processes. TCE was first prepared in 1864 and found minor use as an anesthetic in 1933 to 1934. 2yrs? TCE is a primary component in degreasing operations, caffeine extraction from coffee, dry cleaning, and as a chemical intermediate in the production of pesticides, resins, waxes, varnishes and other specific chemicals. PCE, (tetrachloroethylene or



Source: USGS 15 MINUTE QUADRANGLE:
CHARLEVOIX AND BAYSHORE

FIGURE 1-1
VICINITY MAP
CHARLEVOIX SITE



LEGEND

▲ EXISTING MONITORING WELL - INSTALLED BEFORE JANUARY 1984

△ BORING LOCATION - DECEMBER 1988

N

0 500

SCALE IN FEET

FIGURE 1-2
SITE MAP
CHARLEVOIX SITE

perchloroethylene) is a clear, colorless, nonflammable liquid. It has been widely used as a dry cleaning agent, degreaser, chemical intermediate and a fumigant.

The U.S. EPA has proposed recommended maximum contaminant levels (RMCL's) for trichloroethylene and tetrachloroethylene of "0" in drinking water. The Clean Water Act, water quality criteria for human health, drinking water only established the 10^{-5} risk level for TCE at 28 ug/L and for PCE at 8.8 ug/L. The 10^{-5} risk level is defined as that concentration which would be expected to result in one addition incidence of cancer in a population of 100,000 persons exposed to that concentration for an average lifetime of 70 years.

1.2 PROJECT PROGRESSION

The remedial investigation of the Charlevoix site began in September 1983. Preliminary field work began in September and was completed in December with the installation and sampling of 12 borings and monitoring wells. The second major phase of field work began in July 1984 and included soil borings, monitoring well installation, water sample collection, water level data collection and air monitoring. In August 1984, additional water samples and water level data were collected.

Data collected in December 1983 indicated that concentrations of TCE and PCE in the groundwater moving toward the water supply well were much higher than previously measured. A Focused Feasibility Study (FFS) was initiated in early 1984 because of the potential health hazard to Charlevoix residents presented by the contaminated drinking water supply. The purpose of the FFS was to evaluate Immediate Remedial Measures (IRM's) that could be implemented to provide a safe drinking water supply. The FFS recommended that a lake water intake structure and filtration/flocculation plant be constructed to provide Charlevoix residents with a new water supply.

At the completion of the RI, a Feasibility Study (FS) will be conducted to evaluate other remedial action alternatives based on criteria established by the National Contingency Plan in addition to constructing the lake water intake for protecting the public health, welfare, and environment from contaminated groundwater and soil that remain in Charlevoix.

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Chapter 2
SITE INVESTIGATIONS

The objectives of the site investigations were:

- o Determine the location and extent of contamination
- o Locate and quantify the source of contamination

To accomplish these objectives a series of field activities were initiated that included soil borings, monitoring well installations, collection of water samples, field analytical work, air monitoring in suspected confined air spaces and water level mapping. The field activities were organized into two tasks: source identification and source quantification.

2.1 SOURCE IDENTIFICATION

The three objectives of the source identification task were to:

1. Identify the source(s) of groundwater contamination in the Charlevoix municipal well.
2. Define the vertical and areal extent of the TCE and PCE contamination.
3. Define the pathway of contaminant transport through groundwater flow to the municipal well.

The source identification task was divided into the following subtasks:

- o Monitoring well installation
- o Field hydraulic conductivity testing
- o Groundwater sampling and analysis
- o Water level monitoring and water table mapping

2.1.1 MONITORING WELL INSTALLATION

In the initial site visit and data gathering efforts several potential sources of contamination were identified (Figure 2-1). The initial boring locations were planned to identify which of the potential sources were actually releasing contaminants to the aquifer and to define the extent of the contaminated plume.

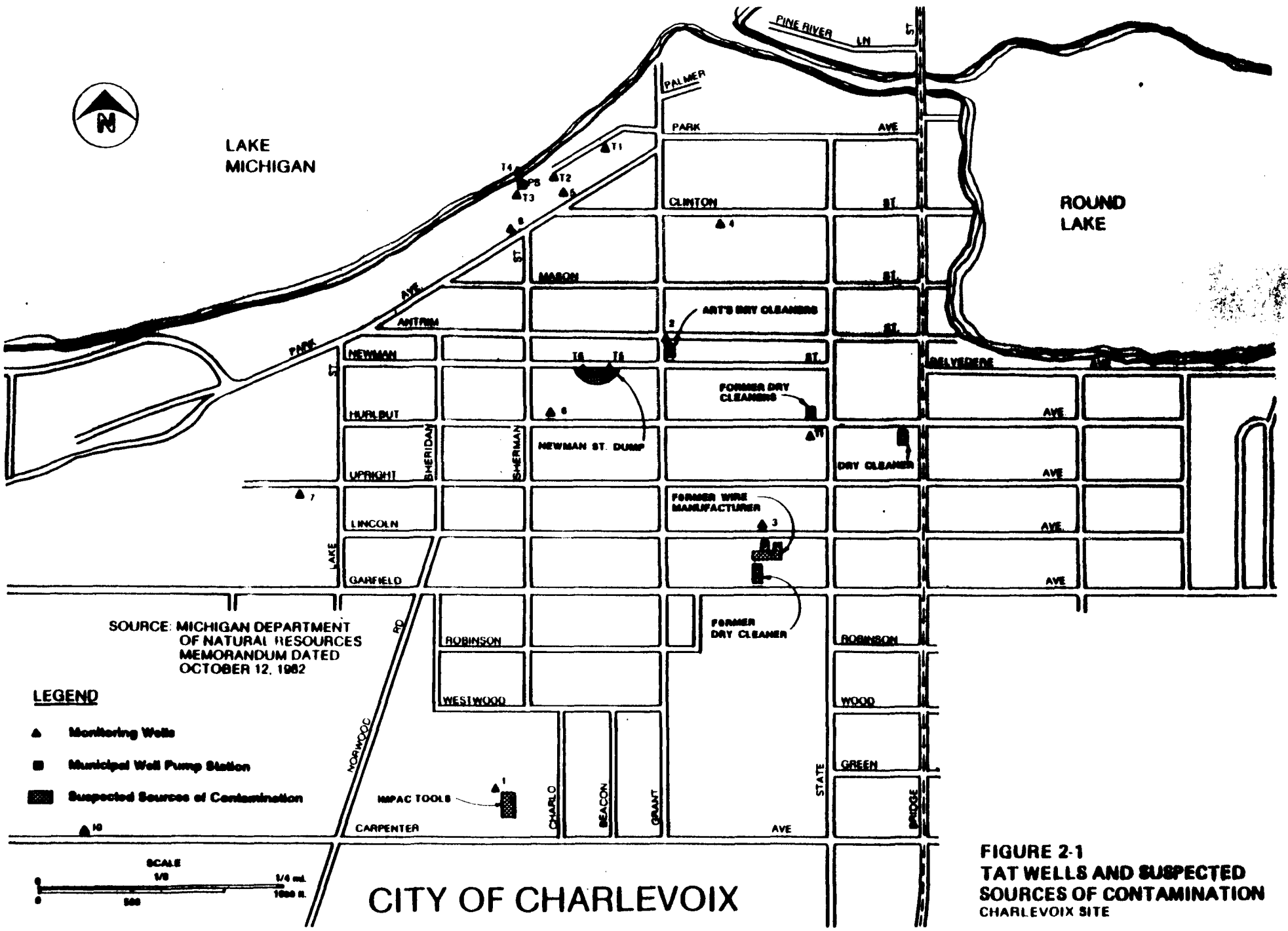


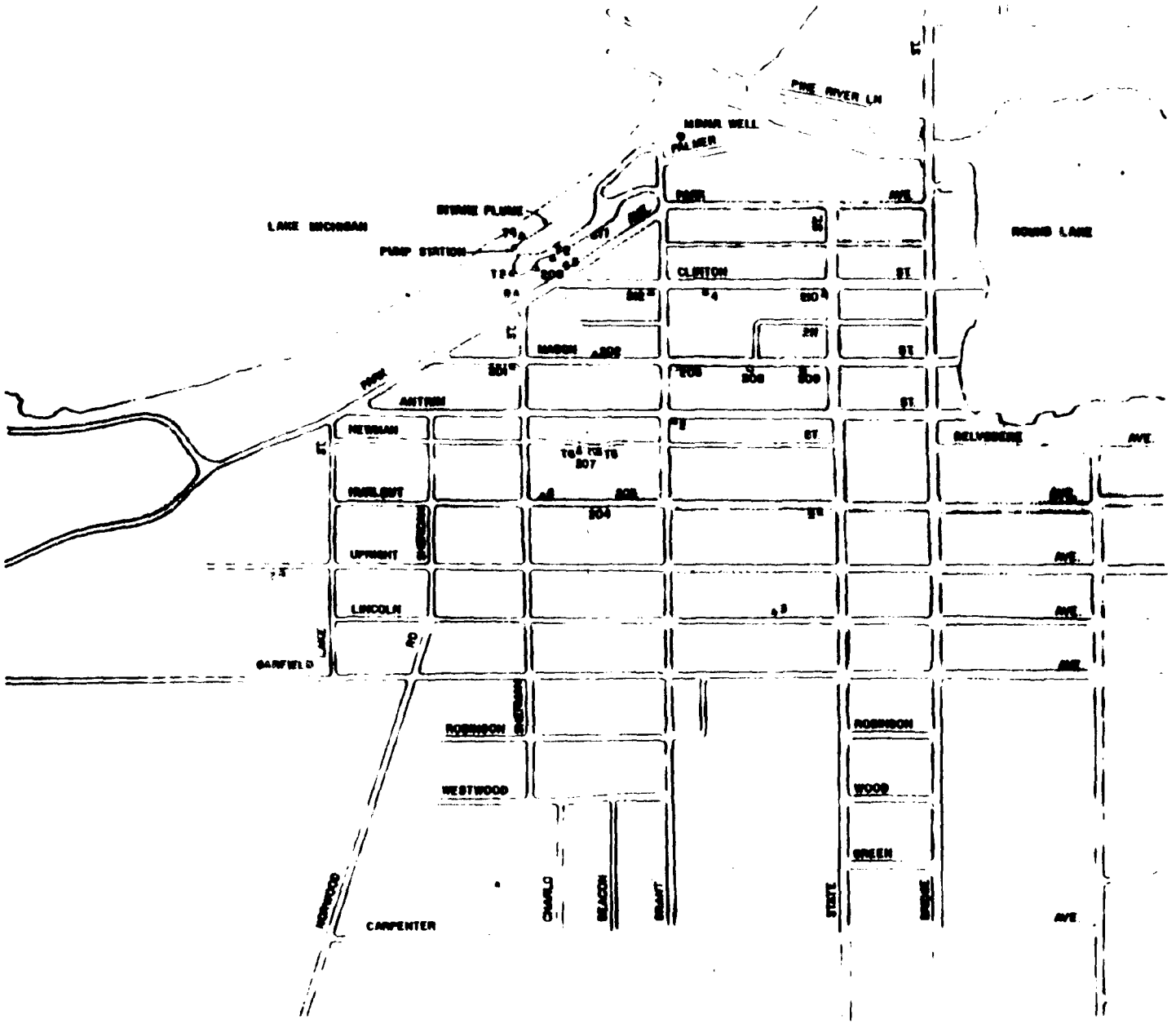
FIGURE 2-1
TAT WELLS AND SUSPECTED SOURCES OF CONTAMINATION
CHARLEVOIX SITE

Six borings were drilled and six monitoring wells were installed at the Charlevoix site in December 1983. These borings are indicated as 200 series wells in maps and figures. The locations of all borings and monitoring wells drilled during this phase of field work are shown in Figure 2-2. The initial three boring locations (201, 202, and 203) were planned to bisect a hypothetical plume that would have been generated from the primary suspected source areas (Art's Drycleaners and the Newman Street Dump). No defineable plume was found at these locations. Additional boring locations were selected by the site hydrogeologist to either identify or discount other potential contaminant sources. Water samples were collected with depth using a screened auger and analyzed with a portable gas chromatograph (Photovac) unit. Monitoring wells were installed in bore holes where contaminants were detected or at locations where water level data points were needed to define the groundwater surface. Details of the boring and monitoring well installation program are included in Appendix A (Task 2 Technical Memorandum).

2.1.2 HYDRAULIC CONDUCTIVITY TESTS

A measure of the ability of an aquifer to transmit water or other liquids is represented by the hydraulic conductivity or permeability of the aquifer. Hydraulic conductivity usually varies from place to place in an aquifer and also may vary depending on which direction the fluid in the aquifer is moving. For example, the vertical hydraulic conductivity of an aquifer may be one-tenth to one-one hundredth of the horizontal hydraulic conductivity. In order to estimate the rates of groundwater movement and also approximate contaminant movement in an aquifer information on the aquifer hydraulic conductivity must be determined.

The method used for this investigation for estimating hydraulic conductivity consisted of displacing a known volume of water in each well, allowing the well to stabilize, removing the displacement tool and rapidly monitoring the recovery of the well to equilibrium again. Each well responded differently and some recovered too rapidly to acquire more than 2 or 3 data points. However, the response of the wells fell within the same general range of values and provided reasonable data for evaluation of groundwater flow rates, aquifer permeability and contaminant transport. The range of hydraulic conductivity values obtained from these test were from 20 ft/day to 140 ft/day. Based on the aquifer response a value of 100 ft/day was used as a representative value for the aquifer as a whole. Combining [illegible] areal plans for hydraulic conductivity with average [illegible] gradient [illegible] ft/ft) and boring log [illegible] yields an estimate of regional groundwater flow [illegible] ft/day. Darcy



Legend

- T3 ▲ MONITORING WELL INSTALLED BY TAT TEAM
- 204 △ BORING LOCATION, DECEMBER 1984
- 200 ▲ MONITORING WELL INSTALLED, DECEMBER 1984

FIGURE 2-2
LOCATION OF TEST BORINGS AND MONITORING WELLS
CHARLEVOIX SITE

2.1.3 GROUNDWATER SAMPLING AND ANALYSIS

Groundwater quality data were collected by two methods, field analysis by a field-portable GC unit (photovac) and laboratory analysis of samples collected and shipped to an EPA certified lab. The field unit was used to provide quick turnaround of samples to allow the field hydrogeologist to make rapid decisions on monitoring well locations, plume concentrations and safety assessments. The laboratory data were used as confirmation of the field data, analysis for additional compounds and lower detection limits.

TCE, PCE only

Groundwater samples were collected in December 1984 from the existing wells and 200 series wells installed in December 1984. The results from this sampling round provided good information on the TCE plume dimensions but did not unequivocally locate the source of the contamination. This sampling round also discovered a contaminated plume of PCE southeast from the TCE plume. Analysis of the data indicated further information was necessary to locate the PCE source area and to better define the area contaminated with PCE.

A new round of water samples were collected in July 1984, prior to installing any additional wells or borings. These samples were analyzed on site with the field GC unit and duplicate samples sent to a laboratory for analysis. Using these results additional borings were initiated in late July to address the above objectives. These boring are indicated as 300 series borings on Figure 2-3.

300 series to locate TCE source better define PCE plume

A final round of water samples were collected in August 1984, from the 300 series wells and additional wells that had consistently shown contamination. Table 2-1 summarizes the results of the water quality sampling rounds at the Charlevoix site.

Wells 2, 4, 20d 212

2.1.4 WATER LEVEL MONITORING AND MAPPING

Water level data were collected in order to map depth to the water table, hydraulic gradients and therefore estimate rates and directions of groundwater flow.

Four rounds of water level measurements (December 1983, April 1984, July 1984, and August 1984) were conducted in combination with other RI activities. The first and third rounds were conducted during groundwater sampling in December 1983 and July 1984. The second round was conducted in April 1984 during the field hydraulic conductivity testing. The wells installed in July 1984 (315, 316, 317, 319 and 320) were sampled and additional water level elevations were measured in August 1984. Water level elevations were also measured in selected existing wells during the August 1984 sampling trip. A summary of water level measurements is included in Table 2-2. Groundwater contour maps were developed for each of the first two rounds of water level

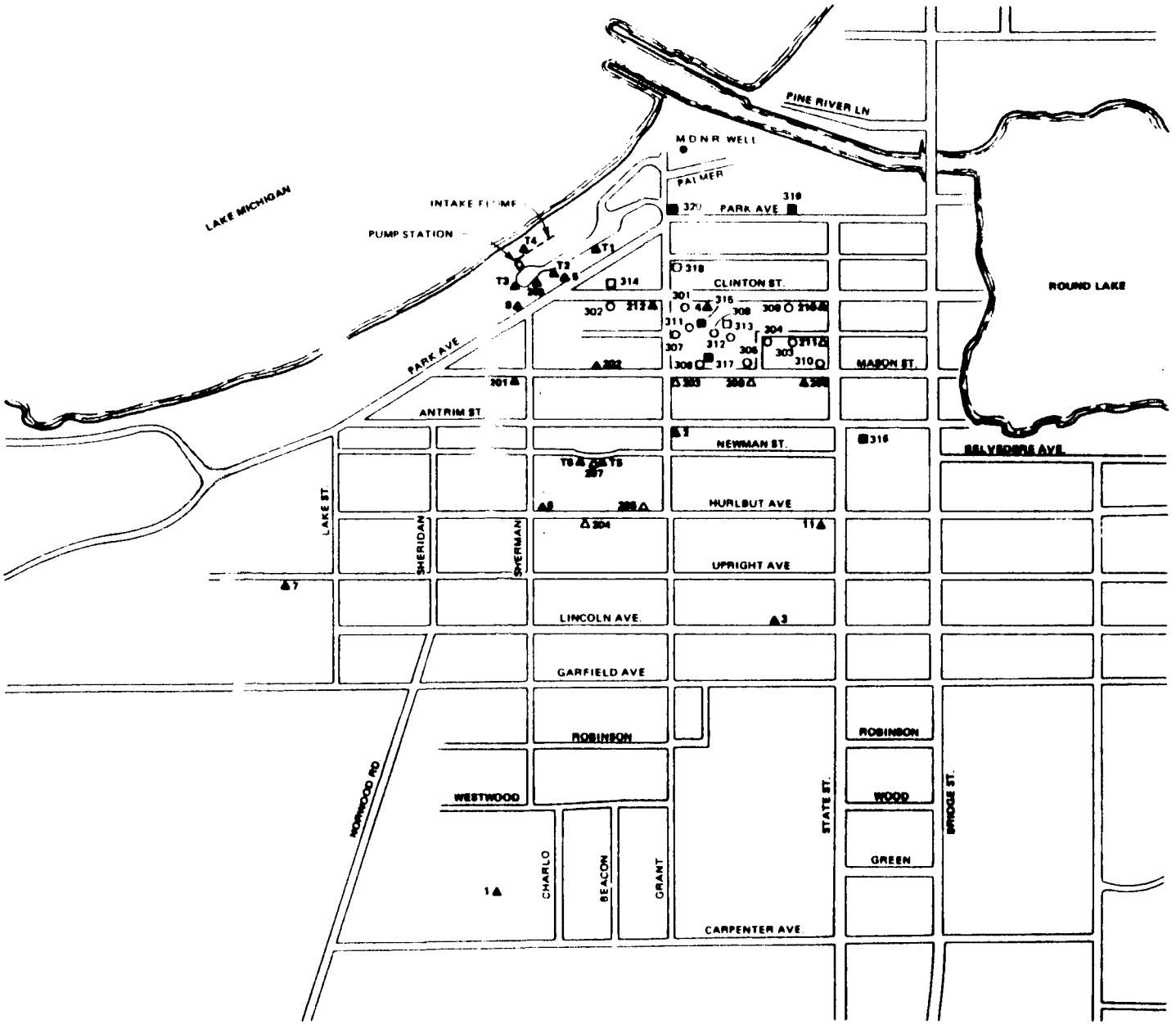


FIGURE 2-3
MONITORING WELL AND BORING LOCATIONS
JULY 1984

Table 2-1 (page 1 of 2)
CONTRACT LABORATORY PROGRAM DATA SUMMARY

Well Number	Trichloroethene-TCE ug/L December 1983	Trichloroethene-TCE ug/L July 1984	Trichloroethene-TCE ug/L August 1984	Tetrachloroethene or Perchloroethene-PCE ug/L December 1983	Tetrachloroethene or Perchloroethene-PCE ug/L July 1984	Tetrachloroethene or Perchloroethene-PCE ug/L August 1984	Other Volatile Compounds Detected and Date
1	*	*(1F)	-	0.6	*(*F)	-	
2	0.6	*(*F)	*	18	16(1.5F)	5K*	
3	*	*(*F)	-	0.8	*(*F)	-	
3 (dup.)	*	-	-	0.6	-	-	
4	480	960(344F)	450	21	5.5(*F)	5.5	
5	*	*(*F)	-	4.3	*(*F)	-	
6	*	*(*F)	-	*	*(*F)	-	
6 (dup.)	*	-	-	*	-	-	
7	*	*(*F)	-	*	*(*F)	-	
8	8.1	10(8F)	-	2.3	*(*F)	-	
8 (dup.)	8.8	10	-	1.7	*	-	
11	8.9	44(8F)	-	340	880(194F)	-	Trans-1,2-dichloroethene 5K* July 12, 1984
11 (dup.)	-	15(8F)	-	-	1,300(194F)	-	
T1	3.0	-	-	2.6	-	-	
T2	405	140(65F)	-	<20	*(*F)	-	
T4	*	*(*F)	-	2.0	*(*F)	-	
T5	5.5	*(1F)	-	2.6	*(*F)	-	
T6	*	*(*F)	-	4.8	*(*F)	-	
201	14	25(23F)	-	1.6	*(*F)	-	
201 (dup.)	11	-	-	*	-	-	

Table 2-1 (page 2 of 2)

Well Number	Trichloroethene-TCE ug/L December 1983	Trichloroethene-TCE ug/L July 1984	Trichloroethene-TCE ug/L August 1984	Tetrachloroethene or Perchloroethene-PCE ug/L December 1983	Tetrachloroethene or Perchloroethene-PCE ug/L July 1984	Tetrachloroethene or Perchloroethene-PCE ug/L August 1984	Other Volatile Compounds Detected and Date
202	5.7	13(15F)	18	2.3	*(*F)	*	
202 (dup.)	-	12(10F)	-	-	*(*F)	-	
206	230	250(200F)	180	54	*(*F)	*	
209	4.0	5K(3F)	-	130	150(119F)	-	
210	0.7	*(3F)	-	11	35(25F)	-	Acetone 9.8 ug/L 7/12/84
212	730	510(422F)	280	<50	*(*F)	*	
212 (dup.)	660	580(406F)	-	110	*(8F)	-	
231 (DNR Well)	2.2	-	-	67	-	-	
315	-	-	850	-	-	9.4	
315 (dup.)	-	-	920	-	-	9.5	Toluene 5K* 8/20-84
316	-	-	*	-	-	21	
317	-	-	*	-	-	29	
319	-	-	9	-	-	11	
320	-	-	14	-	-	*	

Field (Photovac) screening results for samples collected concurrently with CLP samples are designated with a 'F' and listed in parenthesis

K* indicates compounds detected at below the detection limit (5 ug/L), but greater than zero for July 1984 sampling round

* indicates compound not detected

- indicates no sample collected

December 1983 samples analyzed by the purge/trap technique using gas chromotography and a halide-specific detector - EPA Method 601

July 1984 samples analyzed using the purge trap technique with GC/MS - EPA Method 624

10^{-5} cancer risk concentration for TCE=2 8 ug/L

10^{-5} cancer risk concentration for PCE=8.8 ug/L

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Table 2-2
GROUNDWATER LEVEL SUMMARY
(page 1 of 2)

Well Number	Depth of Well Feet Below Ground Surface	Top of Casing Elevation Feet Above msl	Depth to Water Feet Below Top of Casing	Water Level Elevation Feet above msl	Date Measured
1	46.0	643.35	30.12	613.23	12/20/83
			16.48	626.87	04/16/84
			29.86	613.49	07/11/84
2	36.0	607.31	24.88	582.43	12/21/83
			24.94	582.37	04/16/84
			24.49	582.82	07/11/84
			24.49	582.82	08/30/84
3	68.0	641.16	54.65	586.51	12/20/83
			54.38	586.78	07/11/84
4	34.6	610.00	29.40	580.60	12/21/83
			29.29	580.71	04/16/84
			28.71	581.29	07/11/84
			28.98	581.02	08/30/84
5	56.5	628.80	49.56	579.24	12/21/83
			48.36	580.44	04/16/84
			48.07	580.73	07/11/84
6	53.0	625.35	40.17	585.18	12/20/83
			40.19	585.16	04/16/84
			39.92	585.43	07/11/84
7	37.0	620.43	22.27	598.16	12/20/83
			20.96	599.47	04/16/84
			21.58	598.85	07/11/84
8	57.0	626.90	46.62	580.28	12/21/83
			46.36	580.54	04/16/84
			46.08	580.82	07/11/84
11	67.0	638.00	54.18	583.82	12/20/83
			54.02	583.98	04/16/84
			53.75	584.25	07/11/84
T1	27.8	596.89	16.84	580.85	12/21/83
			15.84	581.05	07/11/84
T2	25.5	595.11	15.50	579.61	12/21/83
			14.73	580.38	04/16/84
			14.54	580.57	07/11/84
T3	24.0	591.47	12.12	579.35	12/21/83
T4	21.0	587.00	8.00	579.00	12/21/83
			6.79	580.21	07/11/84
T5	36.0	612.95	29.57	583.38	12/21/83
			29.28	583.67	07/11/84
T6	34.5	614.42	31.09	583.33	12/21/83
			31.15	583.27	04/16/84
			30.78	583.64	07/11/84

Table 2-2
GROUNDWATER LEVEL SUMMARY
(page 2 of 2)

Well Number	Depth of Well Feet Below Ground Surface	Top of Casing Elevation Feet Above msl	Depth to Water Feet Below Top of Casing	Water Level Elevation Feet above msl	Date Measured
201	51.5	615.66	34.56	581.10	12/21/83
			34.54	581.12	04/16/84
			34.04	581.62	07/11/84
202	68.5	613.30	31.95	581.35	12/21/83
			32.10	581.20	04/16/84
			31.48	581.82	07/11/84
			31.60	581.70	08/29/84
206	35.0	594.41	14.17	580.24	12/21/83
			14.04	580.37	04/16/84
			14.00	580.41	07/11/84
			14.38	580.43	08/29/84
209	49.0	611.38	29.99	581.39	12/20/83
			30.00	581.38	04/16/84
			29.41	581.97	07/11/84
210	49.0	609.12	28.50	580.62	12/21/83
			28.52	580.60	04/16/84
			27.84	581.28	07/11/84
212	61.0	612.08	31.80	580.28	12/21/83
			31.54	580.74	04/16/84
			30.86	581.22	07/11/84
			30.73	581.35	08/30/84
315	37.0	612.35	30.98	581.37	08/29/84
316	39.0	608.62	25.71	582.91	08/29/84
317	38.0	611.63	29.85	581.78	08/29/84
319	55.0	610.82	31.88	578.94	08/29/84
320	60.0	624.31	43.34	580.97	08/30/84

NOTE: The 16.48 foot (4/16/84) water depth measurement recorded for monitoring well No. 1 may be questionable because of the large difference from the other two water level measurements: 30.12 ft. (12/20 83) and 29.86 (7/11/84).

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measurements as illustrated in Figures 2-4 and 2-5. July and August water level measurements were combined in Figure 2-6.

2.2 SOURCE QUANTIFICATION

The primary objective of the source quantification task was to quantify the source(s) of TCE contamination. A secondary objective was to further assess PCE contamination. The general locations of potential source areas were determined during the December 1983, RI activities. Exact source(s) of TCE and PCE contamination, such as drums, spills, or leaks, were, however, not identified. The primary objectives of this task were therefore revised to further investigate the source of TCE contamination as well as more clearly define the size and extent of the TCE plume. Additional objectives were to assess the horizontal extent of the PCE plume and to better define groundwater flow paths to the north and east of the suspected source area. The purpose of assessing PCE contamination was to evaluate the potential for movement of contaminated groundwater into the municipal well, Round Lake, the Pine River, and possibly Lake Michigan near the MDNR well.

The source quantification task was divided into three major subtasks:

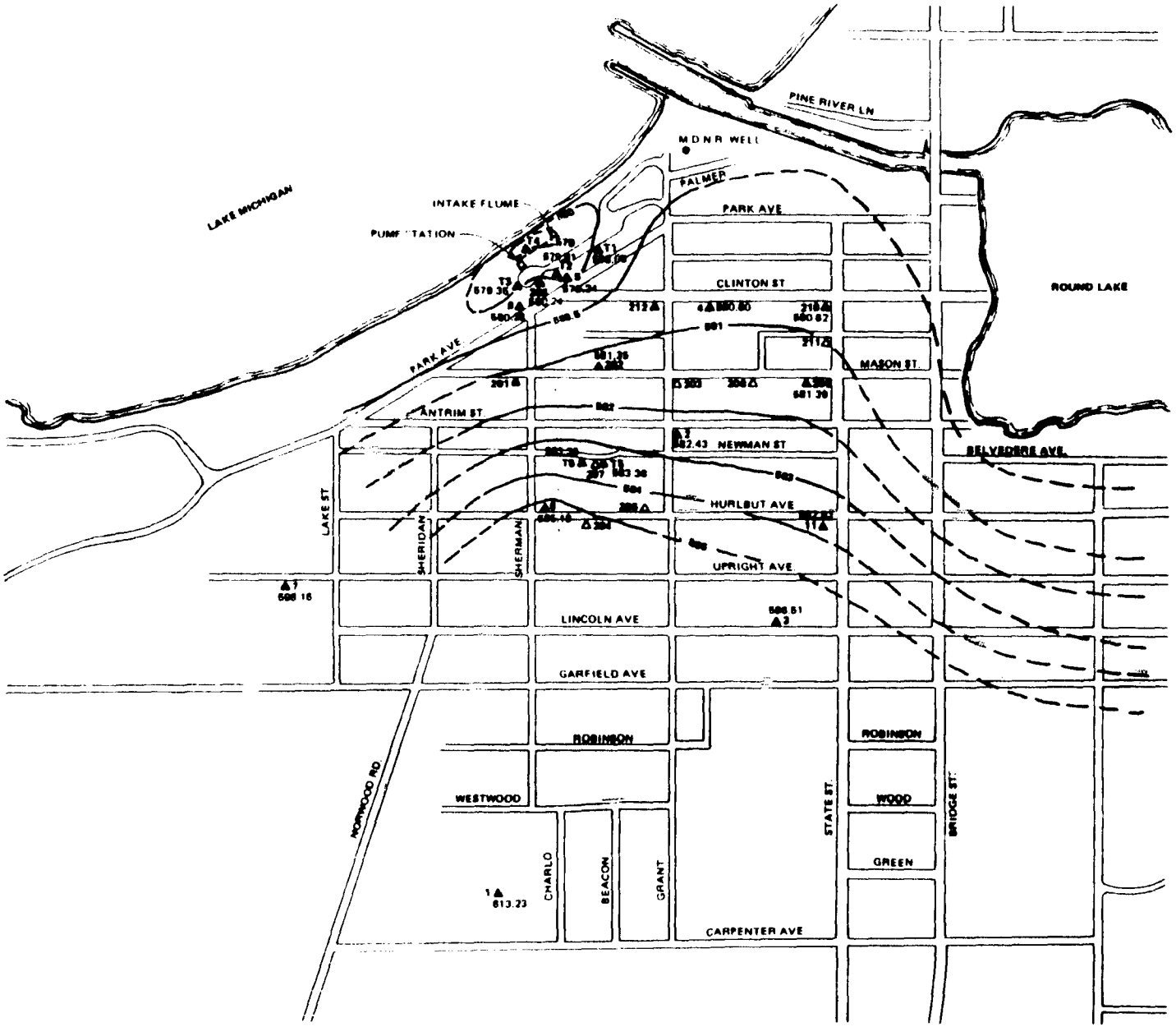
- Air Monitoring
- Shallow Soil Borings
- Deep Soil Borings and Monitoring Wells

Field procedures and technical details involving each of these activities are covered in the technical memorandums, included in Appendix A. Source quantification activities were conducted in July and August 1984.

2.2.1 AIR MONITORING

The purpose of the air monitoring was to determine if organic vapors were present at potentially hazardous levels in buildings, crawl spaces, or storm drains located in areas overlying the contaminated groundwater. A secondary objective of the air monitoring was to search for potential sources of TCE and PCE contamination through the presence of detectable organic vapors in the air.

The inspection was conducted using an HNU PI-101 photoionizing organic vapor analyzer, with a 10.2 electron-volt probe calibrated to benzene. The relative response for both TCE and PCE vapors is approximately equal to 90 percent of the response for benzene on the HNU. The vapor densities for TCE and PCE are 4.53 and 5.83, respectively. Therefore, low spots or areas, such as basements and floor drains, were of major interest.



LEGEND

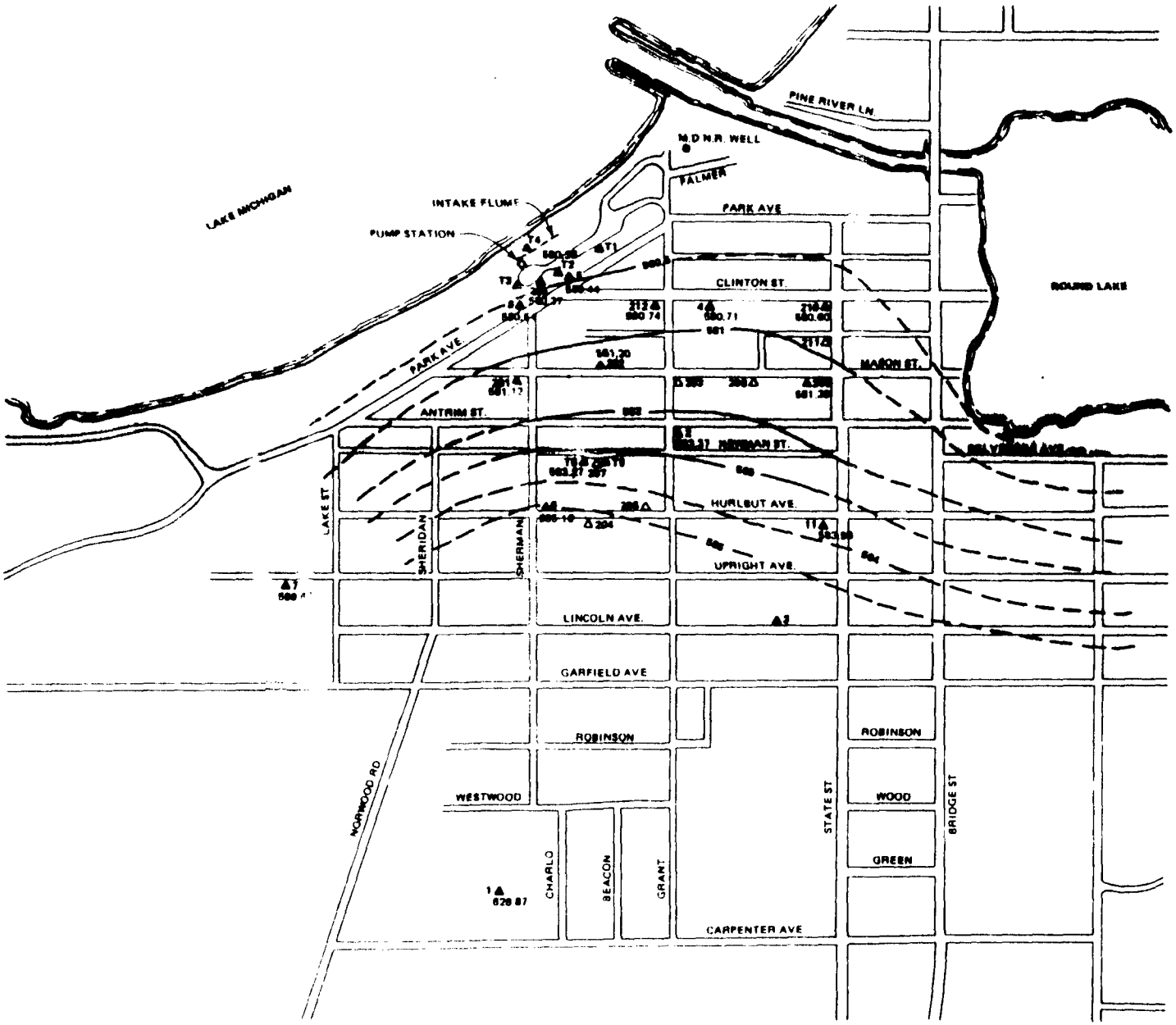
- EXISTING MONITORING WELL WITH WATER LEVEL ELEVATION
- BORING LOCATION
- GROUNDWATER CONTOUR FEET - MSL
- INFERRED CONTOUR

N

0 500

SCALE IN FEET

FIGURE 2-4
GROUNDWATER CONTOUR MAP
DECEMBER 1993
CHARLEVOIX, MICHIGAN



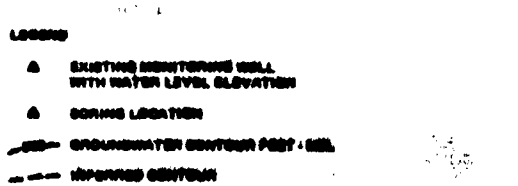


FIGURE 2-5
GOUNDWATER CONTOUR MAP
APRIL 1994
CHARLEVOIX, MICHIGAN

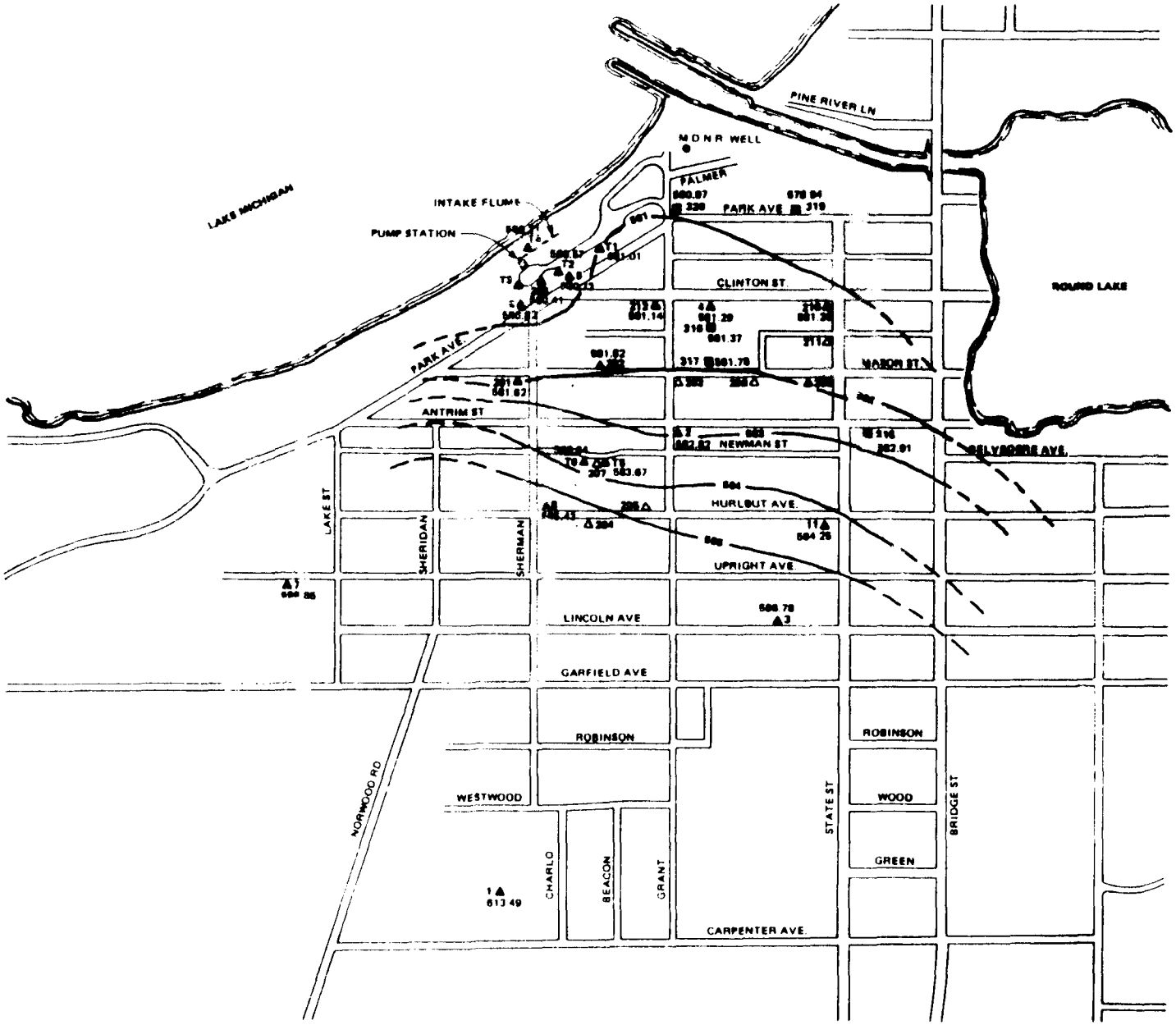


FIGURE 2-6
EXISTING MONITORING WELL LOCATIONS AND GROUNDWATER CONTOUR MAP JULY/AUGUST 1994
CHARLEVOIX, MICHIGAN

The inspection, conducted in and around the nine buildings and the Newman Street Dump site listed in Table 2-3, consisted of surveying basements, crawl spaces, walls, corners, floors, and floor drains in buildings while monitoring with the HNU unit. Monitoring wells and the general ground surface were inspected near the Newman Street Dump.

No detectable concentrations were found that could be related to the groundwater contamination.

2.2.2 SHALLOW SOIL BORINGS

The purpose of the shallow soil borings was to collect soil samples from the unsaturated zone and groundwater samples from the zone just below the water table to identify the source(s) of TCE and possibly PCE contamination. Twelve shallow borings were drilled approximately 5 feet below the water table at the locations shown in Figure 2-3. The approximate total depth of each shallow boring was 35 feet. Fifty-two soil samples and 12 groundwater samples were screened for TCE and PCE using headspace analysis with the Photovac unit.

Shallow soil boring locations were chosen based upon data from existing wells or previously completed borings. Initial locations were selected to intersect the areas of highest known TCE concentrations. As borings were being completed, soil and groundwater samples were screened for TCE and PCE with the Photovac. The results from these screening activities allowed additional boring locations to be selected in areas closer to the source of TCE contamination. The results and analysis from these surveys are discussed in Section 3. The field screening of groundwater samples was successful in defining the area of highest TCE contamination (Table 2-4). TCE and PCE were not detected in high concentrations with the Photovac on any of the soil samples collected in the shallow borings using headspace analysis. Photovac screening results for soil samples are listed in Table 2-5.

The negative results from the soil screening analysis indicate that no residual source of highly concentrated TCE or PCE was penetrated by any of the soil borings. Although there is still a possibility that a buried tank or drum exists in the area it is more probable that the source for the groundwater contamination was a single spill incident. The contaminants are now relatively well dispersed in the groundwater without a continuing source of replenishment or reservoir in the soil or unsaturated zone.

2.2.3 DEEP BORINGS AND MONITORING WELLS

When the shallow borings were completed, deep borings and additional monitoring wells were installed to further assess the extent of the TCE plume. Secondary objectives of this

Table 2-3 (page 1 of 2)
AIR MONITORING SUMMARY

Building or Location	Address	Date and Time Surveyed	Areas Surveyed	HNU Readings ppm-Equivalent to Benzene	Comments
County Annex Building	203 Antrim St.	7/16/84-0900	Outside of building in yard	0.6	Background reading
			Basement		
			- bathroom ceiling	2.2	
			- utility closet	1.2	
			- Building Inspection Offices		
			- ceiling	2.2	
			- northeast office	3.0	
			- north room	2.0	
			- record storage room	0.5	
County Building	Antrim St.	7/16/84-0930	Outside of building in yard	0.2	Background reading
			Basement		
			- hall next to vaults	0.0	
			- boiler room workshop	0.4	
			- furnace room	0.2	
City Hall and Fire Station	Mason St.	7/16/84-0945	Basement		
			- east storage room	0.5-1.0	
			- Police storage room	6.0-12.0	Room poorly ventilated with several gasoline containers
			- outside of Police storage room	1.0	
			- crawl space near stairway	0.5	
			- women's lounge	0.5	
B.J. Goodwin's (formerly Art's Drycleaners)	230 Antrim St.	7/16/84-1020	Basement		
			- along walls	0.5-0.8	
			Back storage room		
			- general area	0.5	
			- 6-inch drain	300	Drains formerly used for dry-cleanings
			- small drains along west wall	10-120	No longer being used
			Back shed		
			- along dirt floor	0.5	
			Outside along edge of buildings	3.0-7.5	
Newman St. Dump Site	Newman St.	7/16/84-1110	Well T5	0.0	
			Surface soil around site	0.0	

Table 2-3 (page 1 of 2)

Building or Location	Address	Date and Time Surveyed	Areas Surveyed	HNU Readings ppm-Equivalent to Benzene	Comments
Charlevoix Middle School	Grant St.	7/16/84-1330	West Wing		
			- northwest corner crawlspace	0.3	4-feet below floor level
			- northwest corner crawlspace	0.3	Crawlspaces all very dry and dusty
			East Wing		
			- north wall crawlspace	0.4	
			Basement		
			- boiler room and laundry room	0.3	
			cleaning equipment storage room	1.0	Slight cleaning solvent odor
			- floor drain near north entrance to basement	0.3	
			Outside		
			- fuel oil tank vent	0.3	
			- playground storm sewer in the track infield	0.0-0.2	
			- monitoring well No. 4	0.0	
			- monitoring well No. 212	0.0	
Winchester's Funeral Home	State St.	7/19/84-1600	Basement		
			- general area, walls, floors	0.0	
			Garage		
			- general area	0.0	
			- floor drain	3.5	
Jack Gordon Residence	206 Clinton St.	7/19/84-1630	Metal garage behind house	0.0	
Rick Bieman Residence	204 Clinton St.	7/19/84-1645	Basement of house	0.0	
Mrs. Barry Wood Residence	207 Mason St.	7/19/84-1700	Basement and crawlspace of house	0.0	
	202 Clinton St.	7/19/84-1715	Shed and barn behind house	0.0	

Table 2-4
SHALLOW BORING FIELD GROUNDWATER DATA SUMMARY

Boring Number	Date Sampled	Sample Number	Sample Depth	Groundwater Level (Feet Below Ground Surface	Sampling Method	Trichloroethene-TCE (concentration-ug/L)	Tetrachloroethene or Perchloroethene-PCE (concentration-ug/L)
301	7/17/84	CVX-GF-301-090	30'	28.0	Bail	194	*
302	7/17/84	CVX-GF-302-033	33'	30.5	Bail	1	*
303	7/18/84	CVX-GF-303-033	33'	26.5	Bail	3	69
304	7/18/84	CVX-GF-304-033	33'	25.6	Bail	2	1
305	7/18/84	CVX-GF-305-033	33'	27.0	Bail	14	2
306	7/18/84	CVX-GF-306-033	33'	27.2	Bail	*	22
307	7/19/84	CVX-GF-307-033	33'	27.5	Bail	*	*
308	7/19/84	CVX-GF-308-033	33'	28.2	Bail	922	8
309	7/19/84	CVX-GF-309-033	33'	25.3	Bail	5	6
309	7/19/84	CVX-GF-309-033D	33'	25.3	Bail	5	5
310	7/19/84	CVX-GF-310-033	33'	27.3	Bail	2	51
311	7/22/84	CVX-GF-311-033	33'	29.1	Bail	192	6
312	7/20/84	CVX-GF-312-033	33'	27.4	Bail	225	14

*Not detected

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Table 2-5

FIELD SCREENING DATA FOR CONTAMINANT CONCENTRATIONS IN SOIL SAMPLES COLLECTED DURING THE RI

Boring Number	Split-Spoon Sample Number	Depth Below Ground Surface (Ft)	TCE Concentration (ug/L)	PCE Concentration (ug/L)	Comments
301	SS-1	5-7	1	0	
	SS-2	10-11.5	0	0	
	SS-3	15-16.5	1	0	
	SS-4	20-21	2	0	
	SS-5	25-26	45	0	Water table at 28 ft. TCE concentration in groundwater is 194 ug/L.
	SS-6	30-31.5	41	0	
302	SS-1	15-17	0	0	
	SS-2	20-21.5	<1	<1	
	SS-3	25-26	0	0	
	SS-4	30-31	0	0	
303	SS-1	2-4	<1	<1	
	SS-2	6-7.5	0	0	
	SS-3	10-12	0	0	
	SS-4	14-15.5	0	0	
	SS-5	18-19	0	0	
304	SS-1	2-4	0	0	
	SS-2	6-8	0	0	
	SS-3	10-12	0	0	
	SS-4	18-20	0	0	
	SS-5	22-24	0	0	
	SS-6	26-28	0	0	
305	SS-1	1-3	0	0	
	SS-2	5-7	0	0	
	SS-3	10-12	0	0	
	SS-4	15-17	0	0	
	SS-5	20-21	0	0	
	SS-6	25-26	<1	0	
306	SS-1	5-7	0	0	
	SS-2	10-12	0	0	
	SS-3	15-16.5	0	0	
	SS-4	20-21	0	<1	
	SS-5	25-26	<1	<1	

Table 2-5 (Continued)

Boring Number	Split-Spoon Sample Number	Depth Below Ground Surface (Ft)	TCE Concentration (ug/L)	PCE Concentration (ug/L)	Comments
307	SS-1	5-7	0	0	
	SS-2	10-12	0	<1	
	SS-3	15-17	0	0	
	SS-4	20-22	0	0	
308	SS-1	5-7	0	0	Dark brown to black fill 0-12' fill.
	SS-2	10-12	<1	0	Dark brown to black fill.
	SS-3	15-17	0	0	
	SS-4	20-22	0	0	
	SS-5	25-27	<1	0	
309	-	-	-	-	No split-spoon samples collected, groundwater sample only.
310	-	-	-	-	No split-spoon samples collected, groundwater sample only.
311	SS-1	5-7	<1	<1	
	SS-2	10-12	0	0	
	SS-3	15-16.5	0	0	
	SS-4	20-21	0	0	
	SS-5	25-27	0	0	
312	SS-1	5-6.5	2	0	Dark brown fill.
	SS-2	10-12	0	0	
	SS-3	15-18.5	0	0	
	SS-4	20-21	0	0	
	SS-5	25-26	0	0	

The detection limit for both TCE and PCE is approximately 1 ug/L using the PHOTOVAC GC.

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effort were to assess the highest concentrations of TCE at or near the source, [redacted] The scope of work involved installing five additional wells in eight borings, shown in Figure 2-3. Procedures for completing the borings and installing the wells were similar to those used during the source identification task in December 1983.

[redacted] to confirm the [redacted] Two wells, one upgradient (317) and one downgradient (315) from the area of high TCE concentrations were installed. Three additional wells, 316, 319, and 320 were installed to evaluate groundwater flow to the north and east and to further define the PCE plume. Borings 313, 314, and 318 were advanced with screened hollow stem augers to investigate the vertical and horizontal extent of the TCE plume.

A summary of field screening results for the additional deep borings and monitoring wells is presented in Table 2-6. Several groundwater samples were screened for TCE and PCE at each sampling depth in order to provide quality control data on the field procedures being applied.

The area of highest TCE concentrations in groundwater were located just below the water table at the Charlevoix Middle School grounds. The highest PCE concentrations were detected at monitoring well 11. The source of TCE appears to be located at the Charlevoix Middle School grounds and the source(s) of PCE appear to be located along State Street, south of Hurlbut Avenue. No organic vapors were detected that could be attributed to TCE or PCE contaminated soil or groundwater in the part-per-million (ppm) range in the locations surveyed with the HNU, except in the floor drains of B.J. Goodwins (formerly Art's Drycleaners). The water quality data from the borings surroundings B.J. Goodwins indicate little or no contamination reaching the water table from this area. The inhalation criteria for both TCE and PCE is 100 ppm for any [redacted] Therefore, B.J. Goodwins is not considered a health hazard or environmental threat at the present time. However, there is a potential for the present soil contamination to contribute to groundwater contamination sometime in the future.

TLV-TWA 100 ppm

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Table 2-6 (page 1 of 2)
NEW WELLS AND DEEP BORINGS FIELD GROUNDWATER DATA SUMMARY

Boring/ Well Number	Date Sampled	Sample Number	Sample Depth	Sampling Method	Trichloroethene-TCE (concentration-ug/L)	Tetrachloroethene or Perchloroethene-PCE (concentration-ug/L)	Comments
313	7/23/84	CVX-GF-313-030A	30'	Pump	[illegible]1	4	
313	7/23/84	CVX-GF-313-030B	30'	Pump	[illegible]7	4	With van engine running
313	7/23/84	CVX-GF-313-030C	30'	Bail	[illegible]9	3	With van engine off
314	7/24/84	CVX-GF-314-040A	40'	Pump	*	*	
314	7/24/84	CVX-GF-314-040B	40'	Pump	*	*	
314	7/24/84	CVX-GF-314-040C	40'	Bail	*	*	
314	7/24/84	CVX-GF-314-050A	50'	Pump	111	*	
314	7/24/84	CVX-GF-314-050B	50'	Pump	128	*	
314	7/24/84	CVX-GF-314-050C	50'	Bail	18	*	
314	7/24/84	CVX-GF-314-060A	60'	Pump	175	*	
314	7/24/84	CVX-GF-314-060B	60'	Pump	150	*	
314	7/24/84	CVX-GF-314-060C	60'	Bail	178	*	
315	7/25/84	CVX-GF-315-725A	37'	Pump	643	*	Well installed 7/24/84
315	7/25/84	CVX-GF-315-725B	37'	Pump	679	*	
315	7/25/84	CVX-GF-315-725C	37'	Bail	554	*	
315	7/25/84	CVX-GF-315-725CD	37'	Bail	589	*	
315	7/25/84	CVX-GF-315-725BD	37'	Pump	732	*	
315	7/25/84	CVX-GF-315-RB1	-	Pump	3	*	Rinse water blank
315	7/25/84	CVX-GF-315-RB2	-	Pump	1	*	Rinse water blank
315	7/25/84	CVX-GF-315-RB3	-	Pump	13	*	Rinse water blank
315	7/25/84	CVX-GF-315-RB4	-	Pump	1	*	Rinse water blank
315	7/25/84	CVX-GF-315-RB5	-	Pump	*	*	Rinse water blank
315	7/25/84	CVX-GF-315-RB6	-	Pump	2	*	Rinse water blank
315	7/25/84	CVX-GF-315-RB7	-	Pump	*	*	Rinse water blank
316	7/26/84	CVX-GF-316-726A	39'	Pump	*	18	Well installed 7/25/84
316	7/26/84	CVX-GF-316-726B	39'	Bail	*	14	
316	7/26/84	CVX-GF-316-726C	39'	Pump	*	14	
316	7/26/84	CVX-GF-316-726AD	39'	Pump	*	19	
317	7/26/84	CVX-GF-317-726A	38'	Pump	2	25	Well installed 7/25/84
317	7/26/84	CVX-GF-317-726B	38'	Pump	1	28	
317	7/26/84	CVX-GF-317-726C	38'	Bail	2	25	
317	7/26/84	CVX-GF-317-RB1	-	Pump	*	*	Rinse water blank
318	7/26/84	CVX-GF-318-47A	47'	Pump	405		

*Not detected

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Table 2-6 (page 2 of 2)

Boring/ Well Number	Date Sampled	Sample Number	Sample Depth	Sampling Method	Trichloroethene-TCE (concentration-ug/L)	Tetrachloroethene or Perchloroethene-PCE (concentration-ug/L)	Comments
318	7/26/84	CVX-GF-318-47B	47'	Pump	519	*	
318	7/26/84	CVX-GF-318-47C	47'	Bail	519	*	
318	7/26/84	CVX-GF-318-RB1	-	Pump	*	*	Rinse water blank
318	7/26/84	CVX-GF-318-RB2	-	Pump	*	*	Rinse water blank
318	7/26/84	CVX-GF-318-RB3	-	Pump	*	*	Rinse water blank
318	7/26/84	CVX-GF-318-62A	62'	Pump	456	*	Rinse water blank
318	7/26/84	CVX-GF-318-62B	62'	Pump	476	*	Rinse water blank
318	7/26/84	CVX-GF-318-62C	62'	Bail	344	*	Rinse water blank
318	7/26/84	CVX-GF-318-62AD	62'	Pump	420	*	Rinse water blank
318	7/26/84	CVX-GF-318-62BD	62'	Pump	440	*	Rinse water blank
318	7/26/84	CVX-GF-318-62CD	62'	Bail	211	*	Rinse water blank
319	7/26/84	CVX-GF-319-47A	47'	Pump	25	9	Rinse water blank
319	7/26/84	CVX-GF-319-47B	47'	Pump	24	10	Rinse water blank
319	7/26/84	CVX-GF-319-60A	60'	Pump	6	18	Rinse water blank
319	7/26/84	CVX-GF-319-60B	60'	Pump	7	23	
320	7/27/84	CVX-GF-320-727	60'	Pump	23	*	Well installed 7/27/84

*Not detected

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Chapter 3
SITE INVESTIGATION DATA ANALYSIS

3.1 LEVEL AND EXTENT OF CONTAMINATION

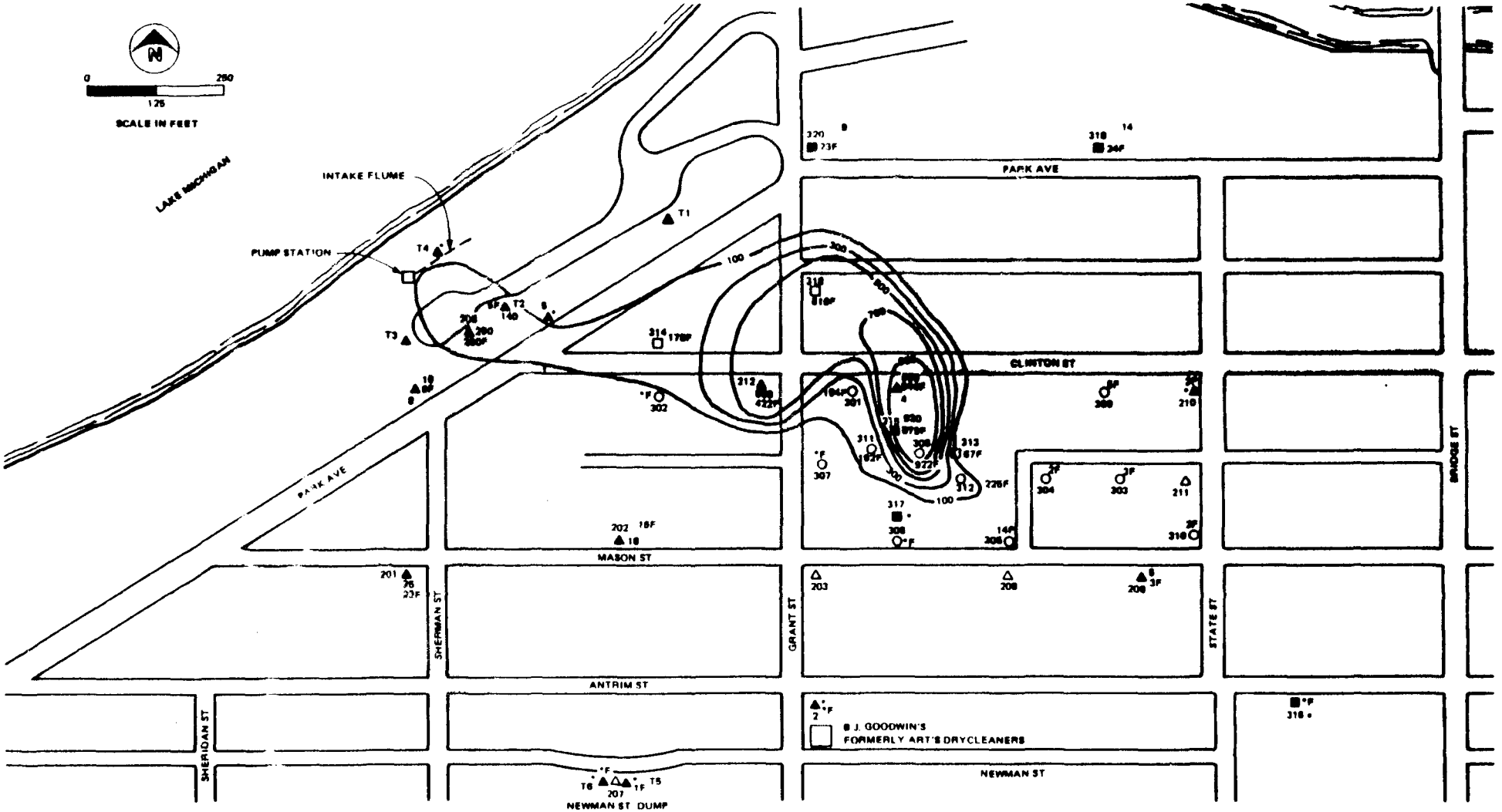
The level and extent of TCE and PCE contamination was assessed using data collected during the drilling and monitoring well installation activities conducted during the source identification and quantification tasks. Contour maps and cross-section maps showing inferred equal concentration contours of TCE and PCE contamination, (Figures 3-1 through 3-4), were produced using field and contract laboratory data from both December 1983 and July/August 1984.

The use of TCE and PCE as solvents, degreasers, drycleaning solvents and chemical intermediates directed the investigations to concentrate in areas suspected of using TCE or PCE presently or in the past.

Shallow soil borings were intended to define the nature of the source of TCE contamination; however, no concentrations of TCE or PCE over 50 ug/L were detected in soil samples collected from the soil borings. The shallow soil boring activity was successful in locating the area of highest TCE contamination in groundwater. The highest concentrations of TCE in groundwater were found in groundwater samples collected just below the water table at the Charlevoix Middle School playground. **Concentrations of greater than 900 ug/L of TCE were found in monitoring well No. 4 and boring 308.** Concentrations of TCE decreased to the west along Clinton Street to the 100 ug/L range near the pump station, as shown in Figure 3-1. The thickness of the TCE plume was estimated to be about 50 to 60 feet at the 206 and 212 boring locations, based on the concentrations shown in Figure 3-2.

The highest concentration of PCE, 1,300 ug/L, was found at monitoring well No. 11 (Figure 3-3). PCE concentrations decreased to the north along State Street to less than 25 ug/L. West of Grant Street, PCE was not detected in any of the borings or monitoring wells sampled in July 1984. Data to the south and east of monitoring well No. 11 were limited, with only one monitoring well in the area south of well No. 11.

The total mass of TCE and PCE contained within each plume is very difficult to quantify because of the uncertainties in establishing the zero concentration contour. The mass was estimated, however, using the average concentrations between contours and the assumed plume dimensions shown in Figures 3-1 through 3-4. The plume boundary for the TCE plume was assumed to be an area bounded by State and Sherman Streets on the east and west, and Park Avenue and Mason Street on the north



LEGEND

- 'F' INDICATES FIELD (PHOTOVAC) DATA
- '•' INDICATES TCE NOT DETECTED
- ▲ EXISTING MONITORING WELL LOCATION INSTALLED BEFORE JANUARY 1984
- △ BORING LOCATION COMPLETED DEC 1983
- ○ ADDITIONAL SHALLOW BORING LOCATION JULY 1984
- □ ADDITIONAL SCREENED HOLLOW STEM AUGER BORING LOCATION JULY 1984
- ■ ADDITIONAL MONITORING WELL LOCATION JULY 1984

CONTOUR INTERVAL = 200 ug/l

THE HIGHEST CONCENTRATION WAS PLOTTED FOR WELLS SAMPLED IN BOTH JULY AND AUGUST
ALL CONCENTRATIONS LISTED IN ug/L

FIGURE 3-1
TCE CONCENTRATION MAP – JULY 1984
CHARLEVOIX, MICHIGAN RI

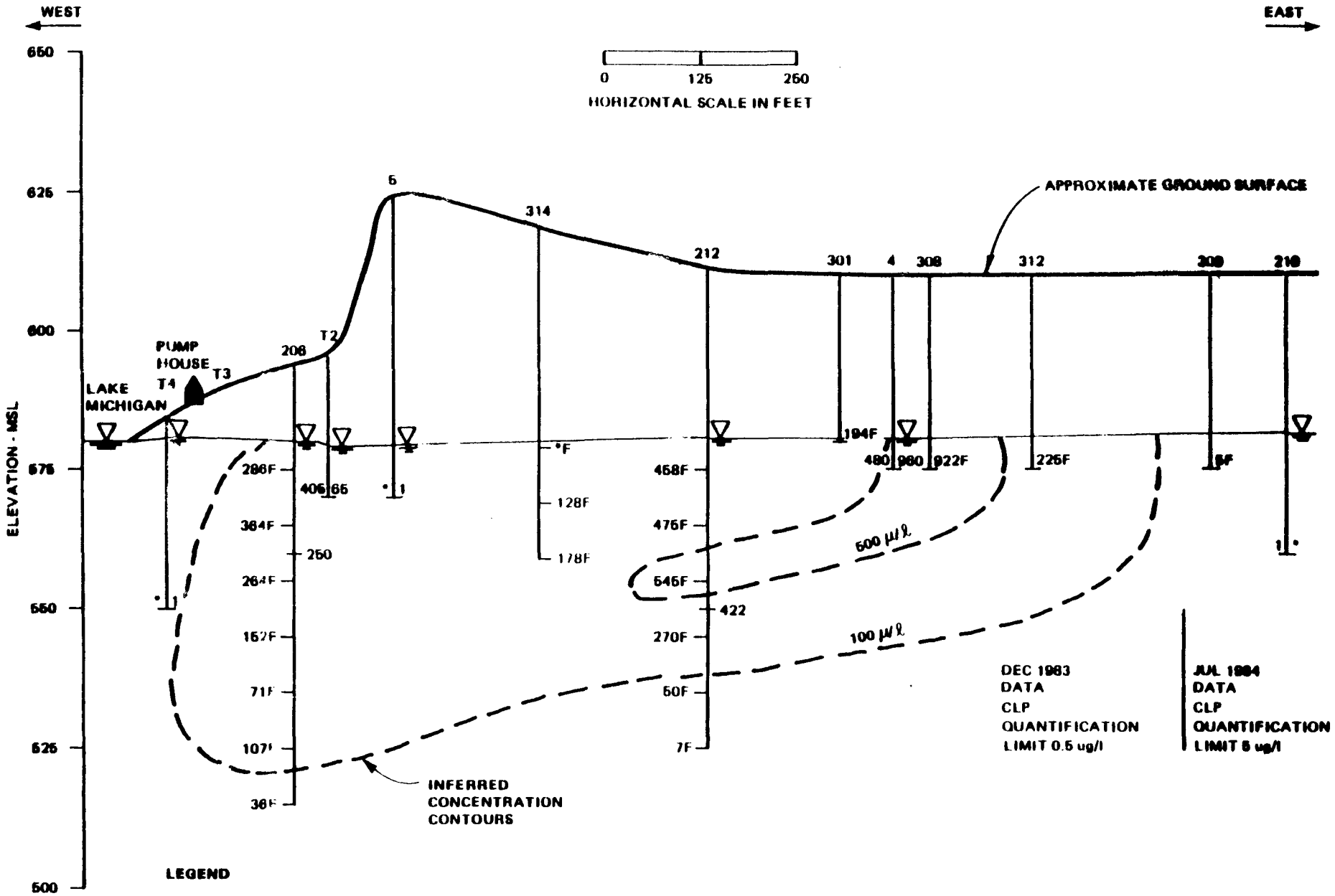
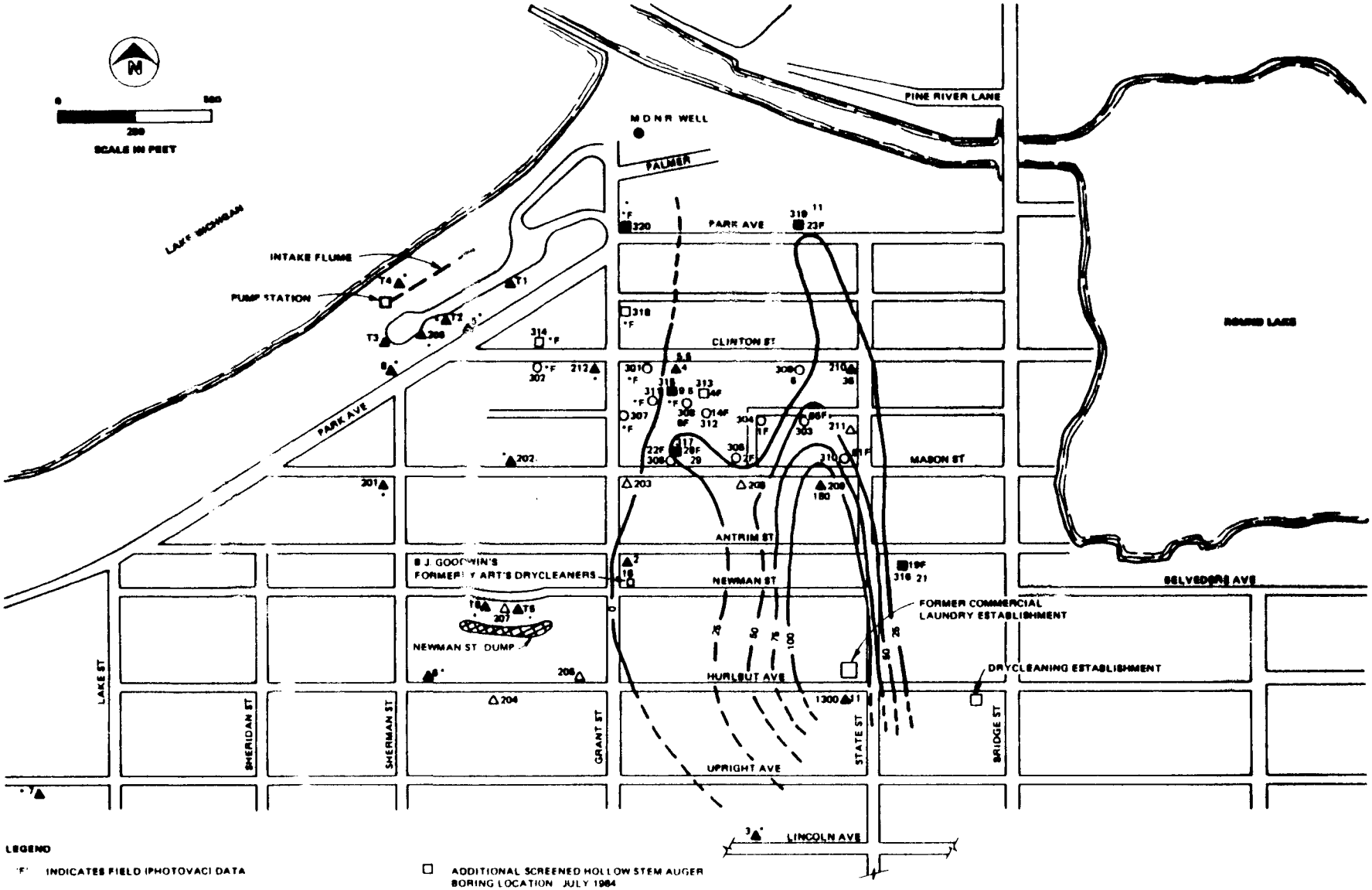


FIGURE 3-2
CROSS-SECTION ALONG CLINTON ST.
CHARLEVOIX, MICHIGAN RI



LEGEND

- 'F' INDICATES FIELD (PHOTOVAC) DATA
- '-' INDICATES PCE NOT DETECTED
- ▲ EXISTING MONITORING WELL LOCATION
- △ BORING LOCATION COMPLETED DEC 1983
- ○ ADDITIONAL SHALLOW BORING LOCATION - JULY 1984
- □ ADDITIONAL SCREENED HOLLOW STEM AUGER BORING LOCATION - JULY 1984
- ■ ADDITIONAL MONITORING WELL LOCATION - JULY 1984

CONTOUR INTERVAL = 25 ug/L
THE HIGHEST CONCENTRATION WAS PLOTTED FOR WELLS SAMPLED IN BOTH JULY AND AUGUST
ALL CONCENTRATIONS LISTED IN ug/L

FIGURE 3-3
PCE CONCENTRATION MAP - JULY 1984
CHARLEVOIX, MICHIGAN RI

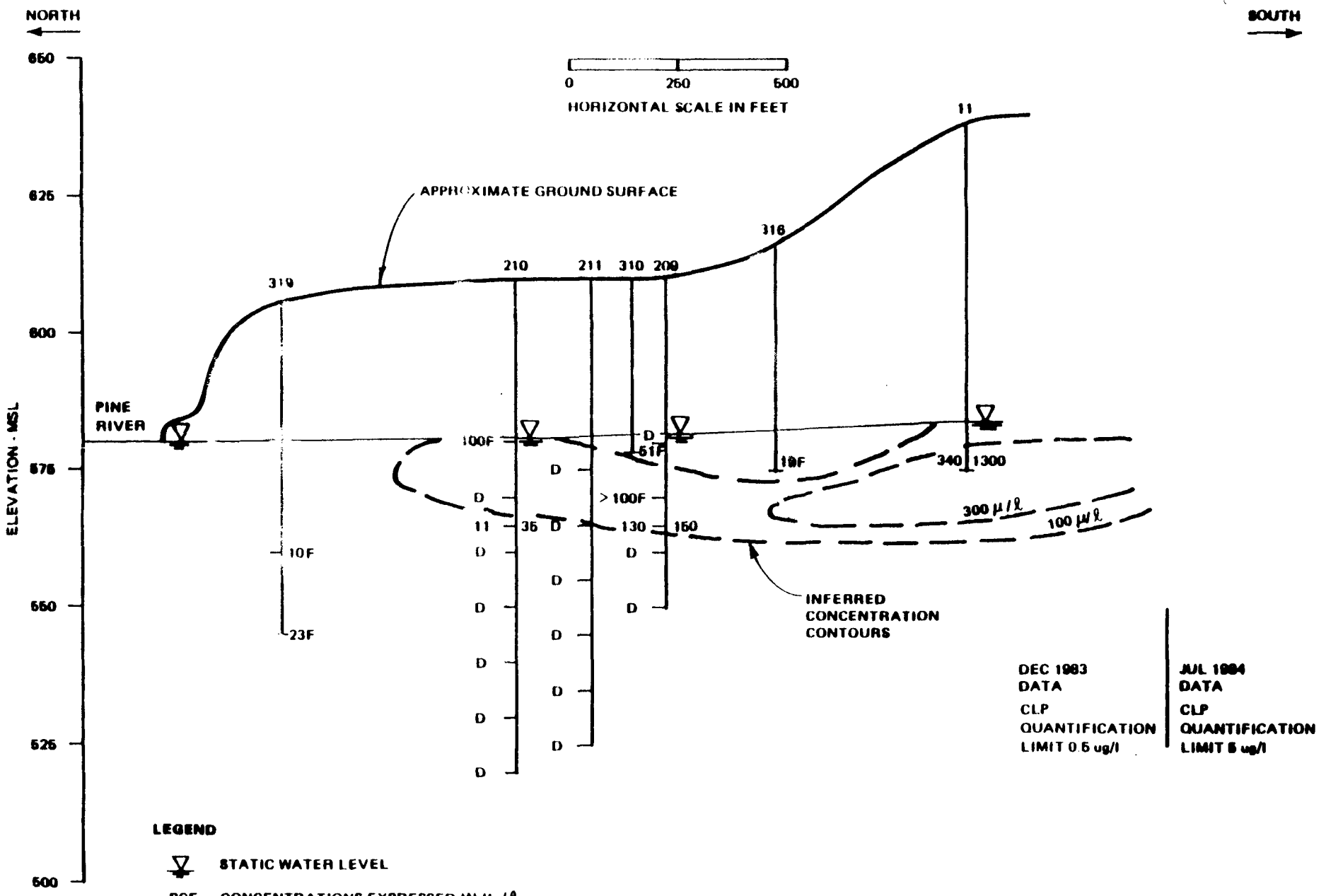


FIGURE 3-4
CROSS-SECTION ALONG STATE ST.
CHARLEVOIX, MICHIGAN RI

and south. The boundary for the PCE plume was assumed to be as shown in Figure 3-3 on the west, and Bridge Street on the east, with Pine River being the northern boundary and Lincoln Avenue assumed to be the southern. The mass of TCE in the plume shown in Figure 3-1 was estimated to be 95 kg, which is equivalent to a volume of about 15 gallons of pure TCE. The total mass of PCE in the plume shown in Figure 3-3 was estimated to be 95 kg, which is equivalent to a volume of about 15 gallons of pure PCE. If these contaminants were the result of a spill the amount spilled would be expected to be considerable larger than what remains in the aquifer at this time due to losses by vaporization and soil adsorption.

3.2 POTENTIAL SOURCES OF CONTAMINATION

The shallow soil borings and the field HNU survey were the two primary tasks designed to identify sources of TCE and PCE contamination. The only HNU readings that were significantly above background were recorded in the police department's storage room, located in the basement of the City Hall building, and in the floor drains located in the back room of B.J. Goodwin's (formerly Art's Drycleaners). The HNU readings noted in the police storage room of 6 to 12 ppm above background were apparently caused by several partially filled gasoline containers stored there. The organic vapor concentrations of greater than 300 ppm recorded in the floor drains at B.J. Goodwin's were apparently caused by PCE vapors. The floor drains were reported to have been used to dispose of dry cleaning solutions when the building was used as a dry cleaning establishment. The Michigan Department of Natural Resources (MDNR) sampled the floor drains to a depth of 15 feet using hand augers and reported that these are open sand drains into the soil beneath the building. PCE concentrations in soil samples collected from the floor drains by the MDNR in 1983 ranged from 110,000 to 460,000 ug/L. A soil sample collected from the 3-foot depth also showed TCE contamination at a concentration of 1,000 ug/L. However, based on the isoconcentration maps (Figures 3-1 and 3-3), neither the police storage room or the floor drains at B.J. Goodwin's appear to be contributing TCE or PCE to the groundwater contamination. Other buildings and areas, including the Newman Street Dump, surveyed with the HNU did not show any readings significantly above background, as listed in Table 2-3.

Soil samples collected from borings 308, 312, and 313 (Figure 3-5) indicated fill material had been placed to depths of up to 14 feet at boring 308. The existence of this fill was confirmed through discussions with Charlevoix School District personnel. According to school district personnel, a wing of the school was originally located in the area where the playground is now located. This wing was reportedly demolished in the early to mid-1950's. The basement of the old wing was filled with soil of unknown origin. Later, in the

LEGEND

- ▲ MONITORING WELL INSTALLED BEFORE JANUARY 1984
- ■ MONITORING WELL INSTALLED JULY 1984
- □ SCREENED AUGER BORING - JULY 1984
- ○ SHALLOW SOIL BORING - JULY 1984
- ///, WING OF SCHOOL CONSTRUCTED IN THE 1960's
- 100 TCE CONCENTRATION CONTOUR IN GROUNDWATER (ug/L) JULY-AUGUST 1984 DATA
- • INDICATES NO TCE DETECTED
- F INDICATES FIELD (PHOTOVAC) DATA

ALL TCE CONCENTRATIONS ARE EXPRESSED IN (ug/L)

N

0 250

125

SCALE IN FEET

FIGURE 3-5
CHARLEVOIX MIDDLE SCHOOL GROUNDS
CHARLEVOIX, MICHIGAN

late 1950's a new, smaller wing was added to the school south of the playground, which now contains the woodworking shop and a science laboratory (Figure 3-5).

The source of TCE contamination appears to be related to events that have taken place at the Charlevoix Middle School. TCE may have been spilled during the demolition or construction activities that occurred during the early 1950's. TCE was commonly used as a degreasing solvent in the 1950's and may have been used with the construction equipment. It is also possible that some portion of the fill material used in the area of the baseball diamond was contaminated; however, existing data from soil borings do not indicate this. TCE may also have been spilled into floor drains or sewers in or around the old school building. The total estimated mass of TCE in the plume is 95 kg (16 gallons of 100 percent TCE), indicating that a relatively small spill (although greater than 16 gallons) may have been the source of the contamination.

The highest concentrations of PCE were found along State Street near the corner of State and Hurlbut (Figure 3-3). Based on the TCE and PCE concentration maps, Figures 3-1 and 3-3, the source of PCE does not appear to coincide with the source of TCE. Potential sources of PCE contamination are the former commercial laundry, the existing dry cleaning establishment on Hurlbut Street or some other source to the south (Figures 1-2 and 3-3). Other potential sources of PCE contamination may include, but are not limited to, dry cleaning establishments, auto repair shops, the airport, machine shops, and other service facilities. The total estimated mass of PCE in the plume is approximately 95 kg (15 gallons of 100 percent PCE) although this is a much more uncertain estimate because of the lack of data to the south.

3.3 RATE OF CONTAMINANT MOVEMENT

The movement of the contaminant plumes in the Charlevoix aquifer is dependent on the rate and directions of groundwater flow. Under steady state conditions, where the aquifer is relatively unaffected by pumping, the rate of groundwater movement can be approximated using Darcy's Law:

$$Q = KIA$$

where,

Q = flow rate
K = hydraulic conductivity
I = hydraulic gradient
A = cross sectional area through which flow occurs

rearranging,

$$q = Q/A = Ki$$

where,

q = specific discharge = rate at which water flows through a unit cross sectional area of porous material.

The average pore velocity of water traveling in a porous material is obtained by dividing the specific discharge by the effective porosity of the porous material.

$$v_i = q/n$$

where,

v_i = average pore velocity
n = effective porosity

therefore,

$$v_i = KI/n$$

The hydraulic gradient of the Charlevoix aquifer is estimated to be 0.005 feet/feet based on water level data obtained from monitoring wells. The porosity of the aquifer is estimated to be 0.25 to 0.30. Using the field values of hydraulic conductivity from 20 ft/day 140 ft/day, which are typical for the aquifer material, the velocity of groundwater flow is estimated as follows:

Low v_i = (20 ft/day)(.005)/0.30 = 0.33 ft/day
High v_i = (140.1 ft/day)(.005)/0.25 = 2.8 ft/day

The rate at which an organic contaminant moves through an aquifer is often much less than the groundwater velocity because of sorption/desorption effects. The ratio of groundwater velocity to contaminant rate of movement is defined as the retardation factor which is not always a constant. For these calculations, the retardation factor for TCE or PCE is assumed to be approximately 2.5[a]. The rate of contaminant movement is calculated as:

$$v_c = v_i/R$$

where,

v_c = velocity of contaminant
v_i = groundwater velocity
R = retardation coefficient

therefore,

Low v_c = (0.33 ft/day)/2.5 = 0.13 ft/day
High v_c = (2.8 ft/day)/2.5 = 1.12 ft/day

The estimated upgradient end of the 100 ug/L contour line of the TCE contaminant plume is estimated to be approximately 1,250 feet from the municipal well. Assuming the highest estimated rate of contaminant movement (1.12 feet/day), it would take in excess of 3 years for the TCE plume to travel from the area of highest contamination to the municipal well.

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[a] Wilson, et. al., Journal of Environmental Quality, 1981.

The area of highest PCE contamination is estimated to be approximately 2,300 feet from the municipal well. It would take in excess of 6 years for the PCE plume to travel from the area of highest contamination to the municipal well assuming the same retardation factor for PCE as TCE and the highest estimated rate of groundwater movement. Based on the PCE concentration map (Figure 3-3), it will take an additional 2.5 years for the PCE plume to travel approximately 1,000 feet from the monitoring well 317 location to the municipal well.

Clean up of the aquifer either by natural groundwater flow or by pumping is an extended process dependent on the degree of interaction between the aquifer and the contaminants. Each time fresh water flows into a contaminated portion of the aquifer, contaminants adsorbed onto the aquifer skeleton desorb into the groundwater. The relative distribution of the contaminant between the aquifer materials and the groundwater is dependent on many factors.

The length of time for the contaminated plumes to move from their present positions toward and past the municipal well were estimated to be in excess of 20 years in the focused feasibility study. Figure 3-6 from the FFS illustrates the concentrations that were projected to be found at the municipal well from the data available in April 1984. The additional data gathered since that time and presented in this RI report has enabled a more clearly defined picture of the extent, sources and levels of contamination to be developed. Within the limits of the analysis Figure 3-6 demonstrates that an extended period of time, in excess of 20 years, will be necessary for the aquifer to return to near acceptable levels of water quality under natural groundwater flow conditions. Further analysis beyond what was accomplished in the FFS will be presented in the feasibility study for the techniques, costs, and procedures to artificially clean up the aquifer in shorter time frames.

3.4 ASSUMPTIONS AND LIMITATIONS

All concentration maps and cross sections are based on U.S. EPA CLP and field (Photovac) data. The field data are assumed to be equivalent to CLP data for the purposes of this report. If both CLP and Photovac data were available for the same sampling point, the CLP data were considered higher quality and therefore used in the analysis. All conclusions, recommendations, and estimates are drawn from a combination of field and CLP data.

Several study limitations were defined during the remedial investigation. Limitations identified during the RI follow:

- Although extensive soil borings were conducted in the suspected source area of the TCE plume, no

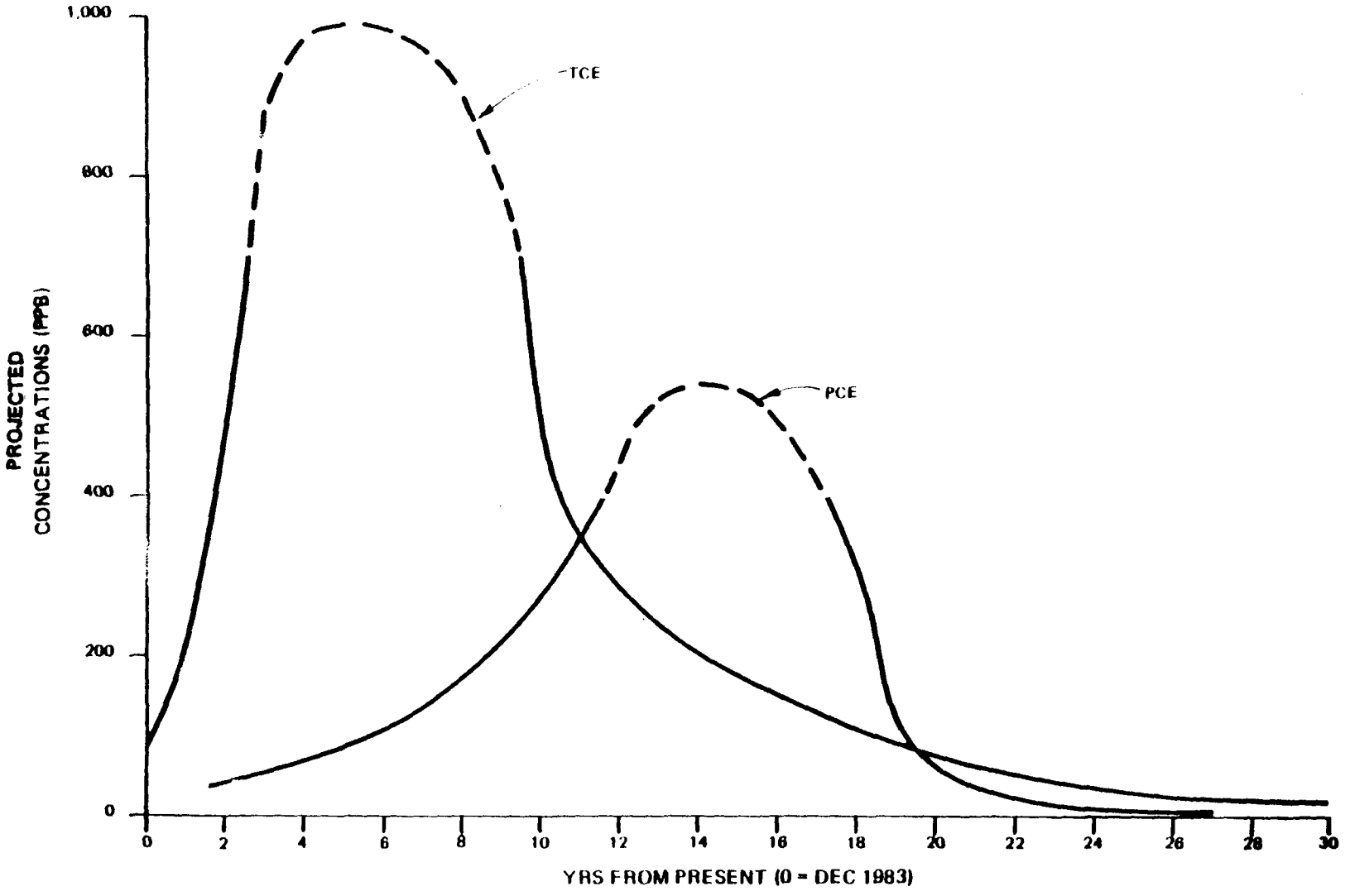


FIGURE 3-6
PROJECTED CONTAMINANT CONCENTRATION AT THE PRESENT WATER SUPPLY WELL
CHARLEVOIX SITE

[redacted] source such as a buried tank or drum [redacted] in addition little or no soil contamination was found. Further work, including additional soil borings or geophysical surveying may locate a discrete source, however, it is not possible to state whether a true source still exists or not.

- The location of the PCE source area is undefined. Well No. 11 found relatively high concentrations of PCE in the groundwater but it is not known if this is the peak concentration or if higher concentrations further upgradient exist. Certainly monitoring of the wells should continue and consideration should be given to additional field work to locate the source of PCE.

- The PCE found in soils near the B.J. Goodwin property represent a potential future source of groundwater contamination. Little or no PCE was found in the monitoring wells in this vicinity. The assumption is that either the PCE has not had sufficient time to move from the soil to the groundwater or it is held firmly in the soils and is not moving. In either case, monitoring of the wells surrounding B.J. Goodwin's is recommended.

Covered by building No groundwater

- The hydraulic conductivity values determined during the RI investigation were derived from procedures that only test a small area immediately surrounding each well. If pumping schemes for aquifer clean up or more accurate predictions of contaminant movement are considered more detailed, extensive tests to derive aquifer parameters are needed.

Pump Tests

3.5 CONCLUDING STATEMENT

The remedial investigation established the extent of TCE contamination in the aquifer supplying water to the city of Charlevoix's municipal well. A plume of PCE was also identified and reasonable limits for this plume inferred. The rate of movement of each of these plumes is estimated to be between 0.13 and 1.12 ft/day. No discrete sources for either TCE or PCE were found. Peak concentrations of TCE are expected to be encountered at the Charlevoix municipal well within the next 3 to 6 years. The presence of PCE is expected to be found in the well within the next 1 to 2 years with the peak concentration occurring in excess of 6 years from the present. The estimated time for the aquifer to naturally flush the contaminants out of the aquifer is in excess of 20 years and based on the analysis from the FFS may exceed 50 years.

2.5 yrs from well #17

Natural flushing 20 yrs at least 5 pore volumes

Included 10 ppb Contours

Appendix A
TASK TECHNICAL MEMORANDUMS

MEMORANDUM DRAFT

TO: Joel Balmat

FROM: Bruce Cutright, Site Project Manager

DATE: February 7, 1984

RE: Task 2.2 Summary Memorandum
Charlevoix, Michigan RI/FS Source Identification
Monitoring Well Installation

PROJECT: W65253.00

1. Timeframe: The drilling crew arrived onsite on November 29, 1983, which completed assembly of the project team. Site activities continued from that date through December 16, including Saturdays and Sundays. After concluding the drilling program, the first set of CLP samples was taken during the period from December 20 to December 23, and processed through special analytical services.

2. Program Participants: The following companies were involved with the various site duties:

A. Supervision - Bruce Cutright, CH2M HILL
Rick Burke, SEG

B. Drilling Services - Paul Valine, GMC Associates, Northville, Michigan

C. Hydrogeology - Ed Everett, Keck Consulting Services, Williamston, Michigan

D. Technicians - Snell Environmental Group, Lansing, Michigan and Keck Consulting Services,, Williamston, Michigan

E. Photovac Operation (field analysis) - Don Woods, Stacy Merrigan, Ecology and Environment, Chicago, Illinois

F. Site Safety Officer - Ecology and Environment, Chicago, Illinois

3. Work Performed: As called for in the work plan, twelve screened auger borings were performed at the site, each to approximately a depth of 100 feet except where drilling could not be performed due to subsurface rocks. Monitor

wells were only installed in those borings where significant contamination (above approximately 3 parts per billion TCE) was obtained during field analysis. During the program, a total of 6 monitor wells were installed in borings 201, 202, 206, 209, 210 and 212.

4. Summary of Results: The attached sketch shows the locations of the borings. The borings are numbered 201 through 212, in the sequence in which they were drilled. The first three borings (201-203) were located to intercept groundwater from previously suspected sources at the Newman Street Dump and Art's Dry Cleaners. Field analysis during the borings indicated that borings 201 and 202 had a low level of contamination (10-15 ppb TCE), and boring 203 had no TCE. Wells were located in borings 201 and 202 because contamination was found and it provides some groundwater elevation data in an area previously without a well.

Borings 204 and 205 are located upgradient of the suspected sources at Art's Dry Cleaners and the Newman Street Dump to attempt to determine if the source of contamination was possibly upgradient of the Newman Street Dump and Art's Dry Cleaners. Both of these borings indicated 0-1 TCE, and no wells were set in this area. Boring 206 was planned at the beach area near Lake Michigan to determine if the groundwater was moving up into the city well from lower elevations, or was moving in the shallow groundwater. Boring 202 showed the suspected higher levels of TCE (200-300 ppb). Concentrations were higher in the shallower elevations of the aquifer.

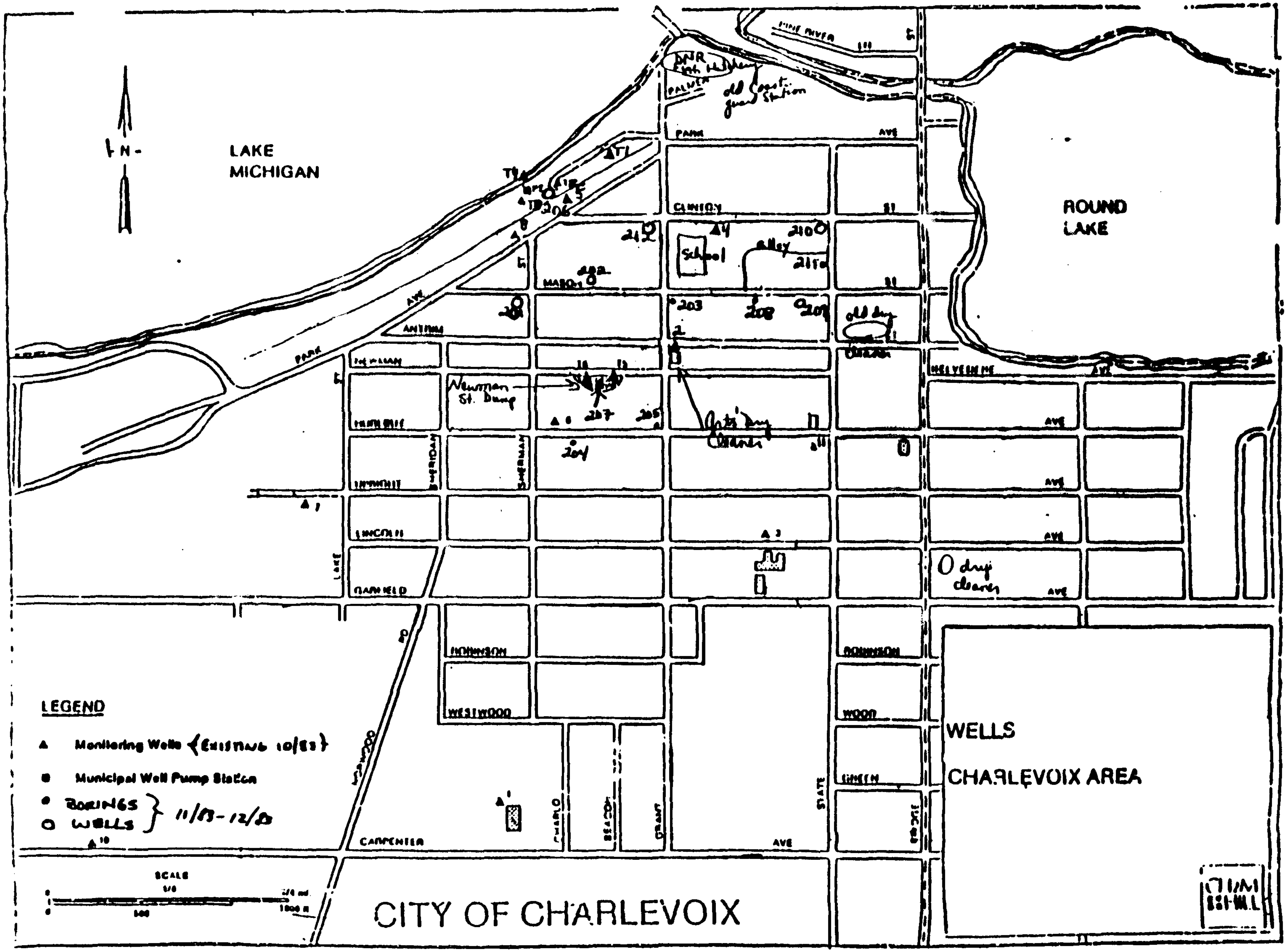
Throughout the program, selected existing monitor wells had been sampled for analysis and generally showed low levels of contamination. While drilling boring 207, samples were taken from monitor well number 4 which had previously been unsampled. Concentrations in monitor well number 4 were found to be in the 200 ppb TCE range. Boring 207 was located in the Newman Street Dump to attempt to locate the minor source of contamination appearing downgradient at borings 201-203, but the TCE concentrations found (6 ppb) did not justify setting a well when two other wells (T5 and T6) were in the immediate area.

The remainder of the drilling program focussed on trying to identify or bracket the source of contamination producing high TCE levels in monitor well number 4. Borings 208 through 211 showed concentrations of TCE in the 1-5 ppb range. The last boring, 212, was located to try to better define the plume and confirm the results of monitor well

number 4. This boring exceeded 500 ppb TCE in the upper 25 feet of the aquifer, and then declined. A monitor well was installed in this boring. Wells were installed in 209 and 210 for future sampling and elevation data.

This concluded the allotted number of screened auger borings and the crew completed work at the site and departed. Site activities in the next phase of operations (Source Qualification) must be reviewed and possibly redefined in light of the findings of the screened auger program. It may be beneficial to install some additional screened auger borings and/or wells to define the source of the contaminated groundwater.

GLT433/33


N
LAKE MICHIGAN
ROUND LAKE
DNR Fish Hatchery
old Coast Guard Station
PARK AVE
School
alley
old dry cleaner
Newman St. Dump
Arts' Dry Cleaner
O dry cleaner
WELLS
CHARLEVOIX AREA
LEGEND
Monitoring Wells {Existing 10/83}
Municipal Well Pump Station
BORINGS } 11/83-12/83
WELLS
SCALE
CARPENTER
AVE
STATE
CITY OF CHARLEVOIX

CHARLEVOIX MUNICIPAL WELL RI/FS
TASK DRAFT TECHNICAL MEMORANDUM

TO: Jack Kratzmeyer, Regional Site Project Officer, EPA Region V

FROM: Bruce Cutright, CH2M HILL, Project Manager
Rick Burke, Snell Environmental Group, Inc.
Ed Everett, Keck Consulting Services

DATE: April 9, 1984

SUBJECT: Charlevoix, Michigan Remedial Investigation
Task 2 - Source Identification Program

JOB NO: W65253.00

INTRODUCTION

The Source Identification Task consists of three major activities: a monitoring well installation program; field hydraulic conductivity testing; and groundwater sampling and level monitoring. The monitoring well drilling program and the groundwater samples for CLP analysis were collected on December 20 and 21, 1983. Hydraulic conductivity testing is scheduled for early April, 1984. The second round of monitoring well sampling and level monitoring will be scheduled if authorized by EPA. Results from those activities will be issued in an addendum to the Task 2 Technical Memorandum.

The work activities herein were performed in partial satisfaction of BOA SC-5-023, Work Assignment No. 46-5L83.0, RI Task 2.

1.0 MONITOR WELL INSTALLATION

1.1 Purpose

The purpose of installing the monitoring wells was to attempt to determine the source(s) of the TCE contamination found in the municipal wells, define the vertical and horizontal extent of contamination in the shallow aquifer, and determine the groundwater flow pattern.

1.2 Scope

The work plan called for approximately 12 borings/wells to be installed during the source identification task. The wells were to be drilled to roughly 100 feet with groundwater samples collected at 10-foot intervals, starting a minimum of 5 feet below saturation. Samples were to be analyzed onsite for TCE and PCE with a field G.C. unit (Photovac). The monitoring wells were to be installed in the zone that showed the greatest concentration of TCE. At locations where no TCE was found, wells were only installed if groundwater elevations were needed.

1.3 Personnel

The project team included personnel from Snell Environmental Group, Inc. (SEG), Keck Consulting Services, Inc. (KCS), Ecology and Environment (E&E), GMC Associates, and CH2M-Hill. The initial site personnel included:

SEG - Rick Burke
Robert Hunt

KCS - Ed Everett
Mark Dunham

E&E - Don Woods

GMC Associates - Paul Velin
Harsit Sidhu
Dean Schultz

CH2M-Hill - Bruce Cutright

Mr. Larry Levingood, Regional Department of Public Health, visited the site frequently to observe the progress of the project. Mr. T. Eftaxiadus, Michigan Department of Natural Resources, visited the site on December 7 and 8, 1983 to observe the work being done. On December 8, Mr. Larry Froebe (E&E) was assigned to the project as site safety officer.

1.4 General Procedure

The locations of all borings and wells drilled during this phase of the field work are shown in Figure 1. The well labeling sequence is as follows:

001 - Wells installed by the TAT team, previously labeled 1, 2, etc.

101 - Wells installed by City of Charlevoix, previously labeled T1, etc.

201 - Wells installed under this Remedial Investigation Contract.

The initial three boring sites (201, 202 and 203) were planned to bisect a plume that would have been generated from the previously suspected sources (Art's Drycleaners, Newman Street Dump). Additional sites were selected by the site hydrogeologist to either demonstrate contribution to the plume or to discount the potential source as a contributor to the plume. Prior to drilling the sites, each location was staked, the property owner or resident was notified (all sites were located within the City right-of-way) and clearance was obtained from Miss Dig.

The boreholes were drilled with 3-1/4-inch I.D. hollow stem augers with the lead auger a screened auger (center 2 feet of auger core constructed of well screen). Auger cuttings were examined by the drilling crew and the site hydrogeologist to determine the glacial stratigraphy. Groundwater samples were collected at 10-foot intervals starting between 5 and 10 feet below saturation. The procedure for sampling was as follows:

1. the augers were air developed at the selected interval to clean fine-grained sediments from the augers and screened section;

2. a minimum of 5 casing (auger core) volumes of water were then pumped from the augers with the Keck SP-81 sampling pump at a rate of approximately 1 GPM;

3. a bailer was used to remove approximately one additional gallon of water and collect the sample;

4. samples were taken in VOA vials and transported to the motel where E&E personnel were analyzing the samples for TCE and PCE with Photovac equipment; and,

5. the air hose, sampling pump and bailer were then decontaminated with TSP solution and a clean water rinse.

Monitoring wells were installed in the boreholes where contaminants were present or at locations where water level data was needed for contouring the groundwater surface. The wells were of PVC construction with 10 feet of PVC #6 slot well screen set in the zone of highest contamination. The annular space of the borehole was grouted with a heavy bentonite slurry (1 pound bentonite/gallon of water) placed from the water table to the surface. A steel well guard with a hinged locking cover was installed over the wells and a cement seal placed around the guard. The wells were air developed after completion.

The drill rig, augers and tools were steam cleaned between each boring.

1.5 Field Work Chronology

Table 1 summarizes the samples collected, level of protection used and the results from onsite testing. Well and boring locations are shown on Figure 1.

November 29, 1983, Tuesday

GMC, Inc. personnel arrived at the location (#201) at 1500 hours and rigged up. Onsite personnel included:

SEG	KCS	CH2M-Hill	GMC
R. Burke	E. Everett	B. Cutright	P. Levin
R. Hunt	M. Dunham		H. Sidhu
			D. Schultz

Visitors

L. Levingood - Regional Health Department
K. Staley - Property Owner, Mayor of Charlevoix
D. Barron - TV 7&4, WPBN, Traverse City

Because of the late start, drilling proceeded to the water table (approximately 36 feet) and was stopped for the day. The augers were left in the borehole ready to proceed on the following day.

November 30, 1983, Wednesday

Onsite personnel included the following:

SEG	KCS	E&E	GMC
R. Burke	E. Everett	D. Woods	P. Levin
R. Hunt	M. Dunham		H. Sidhu

Visitors

S. Baker - Resident
K. Staley
L. Levingood
E. Whitley - City Department of Public Works

We were notified that morning that during shutdown on November 29, D. Schultz had broken his ankle while attempting to disconnect the air compressor from the truck. GMC called their office and requested a replacement.

Weather conditions were cool (approximately 30°F) with strong winds (approximately 60 mph) and occasional snow.

Drilling did not start until 1320 hours due to equipment problems. The bottom plug of the augers was lost at 46 feet and the augers had to be pulled to replace the plug. Drilled to 43 feet and attempted to collect samples from 39 to 41 feet. Much sand and gravel was brought out of the hole during development and a check of the depth indicated more than 3 feet of sand and gravel in the augers. Had to pull augers and grout hole. Planned to move rig approximately 10 feet to start new hole following day.

December 1, 1983, Thursday

Site personnel included the aforementioned personnel, plus S. Merrigan (E&E replacement for D. Woods) and N. Petel (GMC replacement for helper).

The weather was cool (29°F), windy (10-20 mph) with light snow.

Groundwater samples were collected at 40 and 50 feet. Samples were not obtained at 60 and 70 feet because of fine-grained (silty and very fine sand) nature of the materials. At 86 feet, cobbles were encountered and the hole stopped. Measuring the depth inside the augers indicated that there was 5 to 6 feet of sediment inside the augers. Pulled augers back to 83 feet and washed sand from the auger core. Attempted to develop this 80-foot interval; very little water was produced. The augers were pulled back to 73 feet and the casing set through augers. The casing was pushed through the auger plug with an AW rod. While pulling the rod, it was dropped approximately 10 feet. The casing was left in the ground and the augers pulled. Shut down for the night.

December 2, 1983, Friday

The site personnel remained the same except that J. Pincumbe replaced M. Dunham for KCS.

The weather was cool (approximately 24°F) with snow.

The drilling crew pulled casing back to 62 feet, and attempted to develop. No water was being produced so the casing was pulled back to 42 feet and again, no water was produced. Checking the depth indicated that the casing had several feet of sand. The casing was pulled from the hole. The screen had been broken off when the AW rod was dropped. The hole was redrilled to 53 feet and a well set to 52 feet. The hole was grouted, a well guard installed and the well developed.

E. Everett called a meeting of the drilling crew to express concern over work proceedings to date. GMC was requested to provide an additional person and treating equipment to prevent freezing problems encountered to date.

December 3, 1983, Saturday

Site personnel remained the same except that D. Marion replaced N. Petel for GMC. S. Baker, property owner, visited the site frequently during the day.

The weather was overcast and cool (approximately 29°F) with 10 mph winds from the northwest.

The drilling rig was set at location #202 at 1430 after problems with cleaning equipment. The hole was drilled to 48 feet before stopping for the day. Samples had been collected at 35 and 45 feet.

December 4, 1983, Sunday

The site personnel were the same as above with S. Baker, property owner, visiting the site frequently.

The weather was partly cloudy, and cool (23°F), with light winds.

Drilling started at 0820. The drilling proceeded to 91 feet after clay was first detected at 87 feet. Groundwater samples were collected at 55 feet, 65 feet, 75 feet and 85 feet. TCE was detected at low concentrations with 20 ppb found at 65 feet. The rig broke down at 91 feet and the augers had to be straight pulled back to 70 feet. The well was installed through the augers at this depth. The final well setting was 68 feet. After pulling the remaining augers, the hole was grouted from 29 feet to the surface. The well developed clean after air surging for 1 hour.

December 5, 1983, Monday

The site personnel included all previously mentioned people plus J. Simmer, GMC, and R. Day (replacement for R. Hunt, SEG).

M. Conway from TV 29 visited the site and filmed the drilling.

The weather was cool (30°F) with westerly winds and light snow.

The drill rig was set up at location #203 and drilling started at 1215. Saturation was detected at 28 feet below ground level. Groundwater samples were collected at 35, 45, 55, 65, 75, and 85 feet. No TCE was detected in any of the samples and there were only trace amounts of PCE found. The hole was stopped at 88 feet because no significant contamination had been found. A well was not set in this boring and the borehole was plugged with bentonite grout.

Because some of the QA samples were showing some organic carryover from the acetone, it was decided by SEG, KCS and E&E to discontinue using the acetone and do the decontamination with TSP solution and clean water.

Based on the results of the samples from sites #201, #202 and #203, it was decided that the next two borings and wells would be drilled upgradient of the Newman Street Dump and the old hospital building to confirm that no contamination was coming from upgradient at these potential sources. The sites had been cleared by Miss Dig during the initial site clearing. Locations were staked and residents notified by E. Everett.

December 6, 1983, Tuesday

Onsite personnel included:

SEG	KCS	E&E	GMC
R. Day	E. Everett M. Dunbar	S. Merrigan	D. Marion J. Simmer H. Sidhu P. Levin D. Gayan

The drilling commenced at 1100 hours at site #204. Saturation was detected at 50 feet. Samples were collected at 55 and 65 feet. A sample was attempted at 75 feet, however, silt as encountered and very little water was recharging to the augers. Clay was encountered at 81 feet and continued to 98 feet where the hole was stopped. No contamination was found, so no well was set in the borehole. The borehole was grouted with bentonite from 48 feet to the surface.

December 7, 1983, Wednesday

Site personnel were the same as the previous day. T. Eftaxiadus, MDNR, visited the site during the day as an observer.

The weather was cold (18°F) with 30 to 40 mph westerly winds.

The rig was set up at location #205 at 0900. The plug broke out of the bottom of the augers at 45 feet, so the augers had to be pulled and a new plug installed. Saturation was detected at 50 feet. Groundwater samples were collected at 60, 70, 80 and 90 feet. All zones produced high volumes of water during development. There was no contamination detected in any of the samples. No well was set and the borehole was grouted from 48 feet to the surface with bentonite slurry grout.

It was decided by SEG and KCS to redrill well #201 because of the problems encountered during the first efforts at that location in sampling at depths greater than 50 feet. Clearances for additional sites on Clinton Street, State Street and near the pumphouse were called to Miss Dig and assurance for clearing by 12/9 was received.

December 8, 1983, Thursday

Site personnel changed somewhat on this date. J. Pincumbe returned to replace M. Dunham (KCS), J. Sheahan replaced E. Everett (KCS), and Larry Froebe was assigned to the project as site safety officer. T. Eftaxiadus from MDNR visited the site as an observer.

The weather was cold (20°F), windy with snow flurries.

The drill was set up at 0900 to start hole #201a (redrill of site #201). The hole was planned for straight drilling (no screened auger samples collected during drilling). The hole was drilled to 92.5 feet. Several attempts were made to set a well through the augers. After being unsuccessful, the augers were pulled and work stopped.

A groundwater sample was collected from well #4. The analyses showed 330 ppb TCE. Because this was significantly different than the low levels reported by MDNR, it was decided that the well should be resampled on December 9.

December 9, 1983

The site personnel was the same as December 8 after changes were made (as noted above).

The weather was cold (20°F), cloudy and windy (up to 20 mph).

The rig and equipment were still set up over hole #201a. The hole was redrilled to 87.5 feet and several attempts were made to sample through the screened auger. Sampling was not successful which confirmed that the original data collected at this site was accurate and that the formation encountered at depth would not yield sufficient quantities of water to warrant a deep well or additional sampling attempts. The augers were pulled and the hole grouted.

A groundwater sample was collected again from well #4. The results showed 109 ppb TCE, which was still significantly higher than reported by MDNR. Because of this high concentration, additional drill sites were planned up-gradient and downgradient of this well.

December 10, 1983, Saturday

Site personnel remained the same as previous day.

Weather conditions were cold (20°F), cloudy with light winds.

The drill rig was set up at site #206 south of the pumphouse at 1015 after problems getting the rig started were solved. The hole was drilled to a total depth of 93 feet. Groundwater samples were collected at 20, 30, 40, 50, 60, 70, and 80 feet. A sample was not obtained at 90 feet due to clay being encountered at that depth. All groundwater samples showed TCE contamination with the highest concentrations being in the zone from 20 to 40 feet. A well was installed with the screened interval being 25 to 35 feet. The well was air developed after installation.

December 11, 1983, Sunday

Site personnel remained the same as previous day except that R. Day was replaced by R. Hunt (SEG).

Weather conditions were cold (20°F) with winds up to 15 mph from the east. Snow occurred later in the day.

The rig was set up at site #207 (Newman Street Dump) at 1200. The hole was drilled to a total depth of 78 feet with saturation detected at 31 feet. Clay was encountered at 64 feet. Groundwater samples were collected at 41, 51, and 61 feet. The sample at 41 feet showed 6.7 ppb TCE while none was detected in the deeper samples. Because there were already wells at this location, a well was not set in this borehole. After pulling the augers, the hole was grouted with a bentonite slurry from 26 feet to the surface.

December 12, 1983, Monday

Personnel onsite were the same as on previous days.

The weather was cool (32°F) with heavy overcast.

The drill rig was set up and drilling started at 0850 at location #208 which was in the center of the block between State and Grant Streets on the south side of Mason Street. Saturation was detected at approximately 27 feet. Groundwater samples were taken at 30, 40, 50, 60, and 90 feet. Samples were not taken at 70 and 80 feet due to the fine-grained material (sandy clay and fine sand and silt) encountered. The samples collected from the upper part of the aquifer showed very low levels (2.4-4.4 ppb) TCE and just a trace of PCE. The deep sample (90 feet) showed no TCE and just a trace of PCE. Because of the low concentrations of contaminants, a well was not set in this boring. Having encountered a relatively impermeable layer between 69 feet and approximately 80 feet, the hole was grouted from 77 feet to approximately 60 feet. The hole was also grouted from 27 feet to the surface.

December 13, 1983, Tuesday

The site personnel were the same as previous days.

The weather was cool (30°F), overcast with light winds.

The drill rig was set up at location #209 (southeast corner of State and Mason Streets) at 0845. Saturation was detected at approximately 29 feet. Samples were collected at 30 and 40 feet and then the auger plug was lost. The augers were pulled, plug replaced and the hole redrilled. Samples were collected at 50 and 60 feet. Clay was encountered at approximately 71 feet and no further samples were collected. The sample results showed TCE concentrations to be very low (2 ppb or less); however, PCE levels in all samples were reported to be greater than 100 ppb. A well was set to 48 feet with the screened section between 38 and 48 feet. The hole was grouted from 28 feet to the surface. A well guard was installed and the well air-developed.

December 14, 1983, Wednesday

The site personnel remained unchanged from previous days.

The weather was cool (27°F), heavy overcast with light winds.

Drilling commenced at 0900 at site #210 located at the southwest corner of the intersection of State Street and Clinton Street. Saturation was detected at 29 feet. Groundwater samples were collected at 30, 40, 50, 60, 70, 80 and 90 feet. The hole was stopped at 93 feet. Very low or non-detectable concentrations of TCE were found in this boring; however, PCE was found in significant concentrations at all depths. The monitoring well was set to 48.5 feet with 10 feet of screen set from 38.5 to 48.5 feet. The borehole was grouted with bentonite slurry grout 20 feet to the surface. The well was air developed after installing the casing guard.

December 15, 1984, Thursday

Site personnel remained unchanged from previous days.

The weather was cool (29°F), with light winds and snow flurries.

The drill rig was set up at 0835 at site #211 which was on the west side of State Street midway between Clinton and Mason Streets. Saturation was detected at approximately 30 feet. Groundwater samples were collected at 35, 45, 55, 65, 75, and 85 feet. The hole was stopped at 87.5 feet. The samples showed very low concentrations (3.0 ppb or less) TCE; however, they had significant (although unquantified) concentrations of PCE. No well was set in this boring because there were wells in either direction north (#210) and south (#209) of this location. The hole was grouted with bentonite slurry from 27 feet to the surface.

Drilling was started at location #212 (southwest corner of Clinton and Grant Streets) at 1435. Saturation was detected at 31 feet. Groundwater samples were collected at 35, 45, 55, 65, 75, and 85 feet. Very high levels of TCE were detected from 35 to 65 feet with the maximum concentration being over 545 ppb at 55 feet. The concentrations decreased to a low of 7.5 ppb at 85 feet. The monitoring well was set to 61.5 feet with the screened interval being 51.5 to 61.5 feet. The well was air-developed after installing the well guard.

This was the last well drilled during this phase of the investigation. The drilling crew cleaned the rig and left Charlevoix on December 16, 1983.

1.6 Data Summary From Field Work

The analyses of groundwater samples collected during the field work are summarized in Table 1 - Field Data Summary - Onsite Analysis. Drilling logs with notes are in Appendix 1. Notes on the drilling logs were added by Ed Everett (KCS).

2.0 GROUNDWATER SAMPLING AND LEVEL MEASUREMENT

2.1 Purpose

The purpose of the sampling effort was to gather data on trichloroethylene (TCE) and perchloroethylene (PCE) concentrations and groundwater levels on all groundwater monitoring wells associated with the Charlevoix TCE contamination site. The data collection and analysis by the Contract Laboratories also served as a confirmation of previous field analytical data collected during drilling operations. The scope and timing of this sampling activity was determined by U.S. EPA.

2.2 Scope

The scope of the first round of groundwater sampling at the Charlevoix site included the following samples:

A. twenty (20) groundwater monitoring wells;
B. three (3) duplicates;
C. two (2) field blanks;
D. one (1) rinse water sample;
E. one (1) sample from the MDNR fish hatchery well.

One monitoring well (T3) could not be sampled because of prior damage to the well casing, possibly caused by a vehicle.

Groundwater samples were refrigerated in the field and packed according to EPA Contract Laboratory Program (CLP) Protocol. Samples were shipped via Federal Express to the Contract Laboratory either on the day the samples were collected, or the following day. All samples were for volatile organic analysis and were shipped to California Analytical Laboratories, Sacramento, California.

2.3 Personnel

The sampling team included the following individuals and firms:

SEG - Rick Burke
Randy Day

KCS - Mark Dunham

2.4 Groundwater Sampling Procedure

2.4.1 Sampling Strategy

The decision was made to sample all groundwater monitoring wells associated with the site since there had been no previous analysis by a Contract Laboratory. The well samples include those installed during the screened auger drilling program (200 series) as well as the previously existing monitoring wells. The analyses by the Contract Laboratory would also confirm previous field analytical results obtained during the well drilling program.

2.4.2 Well Sampling Equipment

All monitoring wells were purged using a Johnson-Keck Model SP-81 stainless steel submersible pump with an EPDM stator. A 2-inch stainless steel bailer was used for taking all monitoring well samples.

2.4.3 Well Depth and Water Surface Measurement

Before purging each monitoring well, the total depth of the well and the location of the groundwater surface were measured and recorded. The total depth and water surface were both measured with a float type electrical measuring device, similar to those made by Keck Geophysical Instruments. The instrument cable was marked off in 5-foot increments, and the distance from the nearest mark to the top of casing was hand measured with a cloth tape. All measurements were made from the top of the well casing prior to purging and sampling the well.

The float measuring device and cable was decontaminated after each use by rinsing in Charlevoix Township water, drying with a paper towel, and placing the assembly in front of the car heater outlet between sampling sites. The unit was usually completely dry by the time it was used again. This method of decontamination was sufficient in that the wells were purged ten volumes prior to each sampling and the sequence of measurements was proceeding from less contaminated to more contaminated wells. The adequacy of this approach was confirmed by the analytical results of the groundwater samples.

2.4.4 Well Purging

Each monitoring well was purged prior to taking the groundwater sample. The volume of water in each well was calculated based on the total depth of the well and the depth to water surface in the well. The purge water volume was then calculated at ten times the well water volume.

The pump was operated continuously off the vehicle battery with the vehicle engine running for the required purging period. The pump was located near the water surface level in the well during purging to insure a complete turnover of the water column during purging. The purge water was discharged to the street.

2.4.5 Well Sampling

A stainless steel bailer was used for sampling all monitoring wells. The specific procedure involved bailing the well once and discarding the contents of the bailer. Then the bailer was placed in the well again, filled, and the water was used to fill the VOA bottles. The VOA bottles were filled, capped and checked for trapped bubbles. The sample from the MDNR fish hatchery well was collected directly into VOA bottles from a hose bib on the discharge side of the booster pump.

2.4.6 Decontamination

Decontamination procedures included steps to avoid contamination of the sample and well, and to minimize carryover of contaminants from one well to another. In summary, the steps used to minimize contamination were as follows:

A. Sample from the least to most contaminated wells based on groundwater data developed during the drilling program.

B. Decontaminate the outside of all equipment used in the wells, particularly the sampling pump and bailer.

C. Use of decontamination wash and rinse solutions.

Solutions were used in sequence to decontaminate the well sampling equipment. Trisodium phosphate wash (1 cup of TSP per 30 gallons) was used as a decontamination solution. This step was followed by a clean water rinse. All of the water used in the decontamination and rinse solutions was from Charlevoix Township, which prior analysis showed was free of TCE and PCE.

The sample pump was decontaminated by pumping decon solution for five minutes followed by five minutes of pumping clean water rinse solution. No decontamination solutions were recirculated. After passing through the pump, both the decontamination solution and the rinse water were discharged to the street.

The bailer was washed in the decontamination solution and rinsed in clean water. To prevent freezing, the bailer was left in the clean water rinse between sampling locations.

During the day of December 21, 1983, when 15 groundwater wells were sampled, nearly 200 gallons of water were used for decontamination and rinsing. All of these solutions were discharged to the street after passing through the pump or other decontamination use.

2.5 Sampling Chronology

The following chronology summarizes the major activities and events for each day of groundwater sampling work at the Charlevoix site, December 20 through December 22, 1983.

December 20, 1983, Monday

The weather was clear with a low of below 0°F, and a high of 10-20°F, with very little wind. Randy Day of Snell Environmental Group, and Mark Dunham, of Keck Consulting Services, met at the site on Monday morning, obtained decontamination water at Charlevoix Township, and began to sample the monitoring wells. Vehicles on the site were a van and a 4-wheel drive truck. Wells sampled on this day and the sampling are listed below:

Well No.	Sample No.
1	CVX-GL-001-1
3	CVX-GL-003-1
7	CVX-GL-007-1
6	CVX-GL-006-1
11	CVX-GL-011-1

Progress during this first day was less than anticipated since a significant amount of time was lost when the 4-wheel drive vehicle was stuck when trying to reach Well No. 1. Snow depths were 16 to 20 inches. Rick Burke of Snell Environmental Group arrived on the site as Well No. 11 was being sampled. After completing that well, we discussed how operations may become more efficient and productive during the next work day. It was decided to operate both groundwater purging pumps in tandem while a third member of the crew would proceed ahead and take well depths and level measurements. This plan was put into action the following day.

December 21, 1983, Tuesday

The weather consisted of snow with temperatures 10-20°F and an increasing wind throughout the day rising to 15 to 20 mph by late afternoon. Decontamination water obtained at Charlevoix Township and the first samples were taken at approximately 8:30 on Tuesday morning. The groundwaters taken and the order of sampling are as follows:

Well No.	Well No.
2	CVX-GL-002-1
T6	CVX-GL-106-1
T5	CVX-GL-105-1
201	CVX-GL-201-1
	CVX-GL-201-1D
202	CVX-GL-202-1
209	CVX-GL-209-1
210	CVX-GL-210-1
5	CVX-GL-005-1
8	CVX-GL-008-1
	CVX-GL-008-1D
T1	CVX-GL-101-1
T4	CVX-GL-104-1
MDNR Well (213)	CVX-GL-213-1
T2	CVX-GL-102-1
206	CVX-GL-206-1
Rinse Water (280)	CVX-GL-280-1
4	CVX-GL-004-1
212	CVX-GL-212-1
	CVX-GL-212-1D

D = Duplicate

The above samples include a sample taken at the MDNR fish hatchery well (sample labeled 213) which was obtained directly from a hose bib at the discharge of the booster pump.

A sample of the rinse water was taken for analysis by the Contract Laboratory after sampling the high concentration wells T2 and 206, and prior to sampling the remaining two wells (4 and 212) which had known high concentrations of TCE. Subsequent laboratory analyses found the rinse water to have 17 ppb TCE, while the remaining two monitoring wells were both over 400 ppb TCE.

Sampling was completed on December 21, in spite of again getting the 4-wheel drive vehicle stuck while sampling well T4.

All of the samples from the December 20 work and some of the December 21 samples were shipped to the Contract Laboratory for analysis. Federal Express picked up the samples at the motel room.

December 22, 1983, Wednesday

On Tuesday night and early Wednesday morning, paperwork was completed for the remaining samples taken on December 21, and the cooler was packed for shipment. Weather on this day was temperature of 10-20°F, with winds out of the west at 25 to 45 mph. A winter storm was approaching. After completing the paperwork, the samples were driven by Rick Burke to Traverse City, while Randy Day and Mark Dunham returned directly to the Lansing area. The samples were given to Federal Express in Traverse City, Michigan at approximately noon. Roads were closed by the State Police in the Charlevoix area beginning at 2:00 P.M. Wednesday.

2.6 Sample Documentation

A summary of the sample tracking documentation for the groundwater samples is given in Table 2 - Sample Identification Matrix.

2.7 Data Summaries from CLP Analysis

The data obtained from the sampling effort for CLP analysis is presented in the following tables. These tables will be evaluated in conjunction with the analyses obtained during the field drilling effort in another section of the Technical Memorandum.

Table 3 - Field Data Summary, First CLP Sampling

Table 4 - Summary of Organic Analysis

3.0 FIELD HYDRAULIC CONDUCTIVITY TESTING

The work for this subtask has not been completed due to difficulty getting the appropriate equipment and adverse weather conditions. The work is tentatively scheduled for the week of April 9, 1984.

All the "200" series wells will be tested and selected additional wells will also be tested. We estimate that 10 to 12 wells will be tested.

These tests will be conducted as follows:

1. Set pressure transducer into well approximately 20 feet below static water level. Allow the transducer to stabilize (temperature), then check the zero reading.

2. Put sealed tube into the well to displace approximately one gallon of water (to be installed quickly).

3. Start reading meter at selected time intervals until well reaches original water level.

4. Rapidly pull tube from well.

5. Record well recovery at selected time intervals until well reaches original static water level.

6. All equipment will be cleaned between each borehole with TSP solution and a clean water rinse.

We anticipate that this testing will require 2 days of field work. Upon completing the work, an addendum to this Technical Memorandum will be prepared and submitted to CH2M-Hill and EPA.

4.0 ANALYSES OF DATA

4.1 Geological Setting

The borings completed during this field work and other available data shows that the upper 50 to 80 feet of glacial deposits consist of sand to sand and gravel. At varying depths, finer grained soils ranging from silty sands to silty clays, are encountered. The elevations of these less permeable materials are not consistent, varying from a high of 537 feet msl (#209) to below 500 feet msl (#210). The variability of the geology is to be expected considering the high energy depositional and erosional glacial history of this area.

The depth to the water table varies with the changes in topography. Depth to water on the highest elevations is approximately 50 feet, whereas near the pumphouse the depth to water is only 11 feet below ground level.

Material encountered below the level of saturation varies significantly which affects the permeability of the strata and consequently may alter local groundwater flow. The ability to develop water through the screened auger used for drilling allows some evaluation of the relative permeability of the different strata. Many zones were producing more than 10 GPM during development. We estimate that permeability of materials producing these quantities of water to be 150 GPD/ft^2 or greater. The silty sand deposits that were either very difficult or impractical to develop clean are estimated to have permeabilities of 50 GPD/ft^2 or less. Most formations will fall into the range of 50 GPD/ft^2 to 150 GPD/ft^2.

4.2 Groundwater Flow Pattern

Water levels were measured in all wells during the sampling and level monitor subtask. All water levels were measured to the nearest 0.01 foot relative to the top of casings which have been surveyed to USGS Datum. The survey data is attached as Table 3 - Field Data Summary, First CLP Sampling.

The water level elevations were plotted and the resultant contours are shown on Figure 2, Groundwater Contour Map.

The area in which this investigation was conducted is a peninsula that is bounded on the northwest by Lake Michigan, on the north by the channel of the Pine River and to the northeast by Round Lake. These bodies of water are interconnected and have close to the same elevation which is approximately 580 feet mean surface level (msl). The groundwater flow appears to be divided between these surface water bodies while generally flowing north into the study area. The dividing line for splitting flow between Round Lake to the east and Lake Michigan to the west appears to be just west of State Street.

Using the permeability ranges indicated in Section 4.1, we can estimate flow rates for the permeable zones. Estimated flow rates, assuming gradient of .005 ft/ft, are listed below:

Permeability	Flow Rate
50 GPD/ft^2	approx. 0.17 ft/day
100 GPD/ft^2	approx. 0.33 ft/day
150 GPD/ft^2	approx. 0.50 ft/day
200 GPD/ft^2	approx. 0.66 ft/day

4.3 Groundwater Quality

Results from the groundwater sampling have been plotted on maps of the area to show aerial distribution of the contamination. CLP and field results for TCE are shown on Figure 3. Figure 4 shows the PCE results obtained from the CLP analyses. Results below a detection limit of .5 ppb are not shown on the figures.

High levels of TCE were found in wells #102 (405 ppb), #205 (230 ppb), #212 (730 ppb), and #4 (480 ppb). All other wells sampled show some TCE contamination, although most concentrations are very low -- less than 10 ppb except in well #201 (14 ppb). This contamination is apparently centered in a narrow plume that extends from the municipal well, up Clinton Street area to just east of Grant Street.

High levels of PCE were found in wells #11 (340 ppb), #209 (130 ppb), #212 (110 ppb), and #206 (54 ppb). Most other wells sampled show low levels of PCE (generally less than 10 ppb). Until this contamination reaches the area of wells #4 and #212, it does not coincide with the high levels of TCE found.

The source of the PCE and TCE contamination are apparently separated based on where the highest levels of contaminants are first noted (PCE in well #11, and TCE in well #4).

Comparing the groundwater contours and resultant flow directions, it appears that the source of the TCE contamination is within the block south of Clinton Street, north of Mason Street, east of Grant Street and west of State Street. Wells on the east and south sides of this block indicate that only low concentrations of TCE are entering this area from these directions. It is possible that the source could be south of this block and the plume has passed between existing test locations; however, the source would have to be close to Mason Street, otherwise it is likely that lateral dispersion would have caused greater impact at one of the test locations.

The municipal well is creating an artificial groundwater discharge which draws groundwater from the impacted area west of State Street toward it. This municipal well will continue to draw contamination toward it until it is shut down or the plume has been purged through this well. Even considering the highest rate of groundwater flow (0.66 feet per day), TCE will impact this well for a minimum of 4 years assuming that the contamination moves directly with the groundwater. Considering that the average flow rate is probably lower than the 0.66 ft/day, and that some attenuation and release of contaminants will occur in the soils, the problem will persist for many years. The PCE contamination, which is further to the southeast than the TCE, will impact the municipal well for an even longer period of time.

TABLES

TABLE 1

FIELD DATA SUMMARY
CHARLEVOIX, MICHIGAN REMEDIAL INVESTIGATION
SOURCE IDENTIFICATION TASK
ONSITE ANALYSIS

Well No.	Date Sampled	Sample No.	Level of Protection	Sample* Boring Depth	TCE (ppb)	Notes
201	11/30/83	CVX-GF-201-RB1	D	Rinse Water	No Peaks	Clean water before rinsing
201	12/01/83	CVX-GF-201-040	D	40'	11	
201	12/01/83	CVX-GF-201-050	D	50'	9	
201	12/01/83	CVX-SF-201-01	D	Unknown	Back-ground	Soil sample with auger at 72'; HNU reading only
5	12/02/83	CVX-GF-005-12-2	D	---	2.5	
2	12/02/83	CVX-GF-002-12-2	D	---	None	@40 ppb PCE; sampled with pump
201	12/03/83	CVX-GF-201-052	D	52'	10.4	
201	12/03/83	CVX-GF-201-052	D	52'	25.0	Sampled with pump
T5	12/03/83	CVX-GF-105-12-3	D	---	22.5	Sampled with pump
T5	12/03/83	CVX-GF-105-12-3	D	---	17.0	
T6	12/03/83	CVX-GF-106-12-3	D	---	2.0	Sampled with pump
T6	12/03/83	CVX-GF-106-12-3	D	---	2.0	
202	12/03/83	CVX-GF-202-035	D	35'	5.2	
202	12/03/83	CVX-GF-202-045	D	45'	9.0	
202	12/04/83	CVX-GF-202-050	D	50'	6.5	
202	12/04/83	CVX-GF-202-065	D	65'	15.0	Sampled with pump
202	12/04/83	CVX-GF-202-065	D	65'	20.0	Sampled with bailer
202	12/04/83	CVX-GF-202-075	D	75'	3.0	
202	12/04/83	CVX-GF-202-085	D	85'	< 1.0	Soil sample with auger
202	12/04/83	CVX-GF-202-085	D	85'	< 2.0	Sampled with bailer
203	12/05/83	CVX-GF-203-035	D	35'	None	PCE present
203	12/05/83	CVX-GF-203-RB1	D	Rinse Water	None	Dirty
203	12/05/83	CVX-GF-203-045	D	45'	None	PCE present
203	12/05/83	CVX-GF-203-055	D	55'	None	PCE present
203	12/05/83	CVX-GF-203-065	D	65'	None	PCE present
203	12/05/83	CVX-GF-203-075	D	75'	None	PCE present
203	12/05/83	CVX-GF-203-085	D	85'	< 1.0	PCE present
202	12/06/83	CVX-GF-202-12-6	D	---	5.5	
204	12/06/83	CVX-GF-204-RB1	D	Rinse Water	< 1.0	Clean
204	12/06/83	CVX-GF-204-055	D	55'	0.9	
204	12/06/83	CVX-GF-204-065	D	65'	1.4	

TABLE 1

FIELD DATA SUMMARY
CHARLEVOIX, MICHIGAN REMEDIAL INVESTIGATION
SOURCE IDENTIFICATION TASK
ONSITE ANALYSIS

Well No.	Date Sampled	Sample No.	Level of Protection	Sample* Boring Depth	TCE (ppb)	Notes
8	12/07/83	CVX-GF-008-12-7	D	---	33	
205	12/07/83	CVX-GF-205-060	D	60'	None	
205	12/07/83	CVX-GF-205-070	D	70'	None	
205	12/07/83	CVX-GF-205-080	D	80'	None	
205	12/07/83	CVX-GF-205-090	D	90'	None	
205	12/07/83	CVX-GF-205-RB1	D	Rinse Water	< 1.0	Clean
4	12/08/83	CVX-GF-004-12-8	D	---	330	
T1	12/08/83	CVX-GF-101-12-8	D	---	1.7	
T2	12/08/83	CVX-CF-102-12-8	D	---	229	
4	12/09/83	CVX-GF-004-12-9	D	---	109	
4	12/10/83	CVX-GF-004-12-10	D	---	182	
206	12/10/83	CVX-GF-206-020	D	20'	286	
206	12/10/83	CVX-GF-206-030	D	30'	364	
206	12/10/83	CVX-GF-206-040	D	40'	264	
206	12/10/83	CVX-GF-206-050	D	50'	152	
206	12/10/83	CVX-GF-206-060	D	60'	71	
206	12/10/83	CVX-GF-206-070	D	70'	107	
206	12/10/83	CVX-GF-206-080	D	80'	36	
3	12/11/83	CVX-GF-003-12-11-1	D	---	< 1.0	
3	12/11/83	CVX-GF-003-12-11-2	D	---	< 2.0	
11	12/11/83	CVX-GF-011-12-11-1	D	---	19.0	PCE-Evac. 5 Casing Vol.
11	12/11/83	CVX-GF-011-12-11-2	D	---	3.0	PCE-Evac. 10 Casing Vol.
11	12/11/83	CVX-GF-011-12-11-3	D	---	3.0	PCE-Evac. 20 Casing Vol.
207	12/11/83	CVX-GF-207-041	D	41'	6.7	
207	12/11/83	CVX-GF-207-051	D	51'	< 1.0	
207	12/11/83	CVX-GF-207-061	D	61'	< 1.0	
206	12/12/83	CVX-GF-206-12-2	D	---	300	
208	12/12/83	CVX-GF-208-030	D	30'	2.4	PCE present
208	12/12/83	CVX-GF-208-040	D	40'	3.3	PCE present

TABLE 1
FIELD DATA SUMMARY
CHARLEVOIX, MICHIGAN REMEDIAL INVESTIGATION
SOURCE IDENTIFICATION TASK
ONSITE ANALYSIS

SHOULD READ CREATED THAN 100 PPB

>100 PPB

Well No.	Date Sampled	Sample No.	Level of Protection	Sample* Boring Depth	TCE (ppb)	Notes
209	12/13/83	CVX-GF-209-RB1	D	Rinse Water	< 1.0	
209	12/13/83	CVX-GF-209-030	D	30'	< 1.0	PCE present
209	12/13/83	CVX-GF-209-040	D	40'	2.0	@7100 ppb PCE
209	12/13/83	CVX-GF-209-050	D	50'	< 2.0	PCE present
209	12/13/83	CVX-GF-209-060	D	60'	< 1.0	PCE present
209	12/14/83	CVX-GF-209-12-14	D	---	1.5	PCE present, well sample
210	12/14/83	CVX-GF-210-RB1	D	Rinse Water	< 1.0	Clean
210	12/14/83	CVX-GF-210-030	D	30'	< 1.0	@100 ppb PCE
210	12/14/83	CVX-GF-210-040	D	40'	2.0	PCE present
210	12/14/83	CVX-GF-210-050	D	50'	2.1	PCE present
210	12/14/83	CVX-GF-210-060	D	60'	5.0	PCE present
210	12/14/83	CVX-GF-210-070	D	70'	2.5	PCE present
210	12/14/83	CVX-GF-210-080	D	80'	1.5	PCE present
210	12/14/83	CVX-GF-210-090	D	90'	1.5	PCE present
T4	12/14/83	CVX-GF-104-12-14	D	---	< 1.0	
211	12/15/83	CVX-GF-211-RB1	D	Rinse Water	None	Clean
211	12/15/83	CVX-GF-211-035	D	35'	3.0	PCE present
211	12/15/83	CVX-GF-211-045	D	45'	3.2	PCE present
211	12/15/83	CVX-GF-211-055	D	55'	3.0	PCE present
211	12/15/83	CVX-GF-211-065	D	65'	2.3	PCE present
211	12/15/83	CVX-GF-211-075	D	75'	1.8	PCE present
211	12/15/83	CVX-GF-211-085	D	85'	1.8	PCE present
212	12/15/83	CVX-GF-212-035	D	35'	458	
212	12/15/83	CVX-GF-212-045	D	45'	475	
212	12/15/83	CVX-GF-212-055	D	55'	> 545	
212	12/15/83	CVX-GF-212-065	D	65'	270	
212	12/15/83	CVX-GF-212-075	D	75'	50	
212	12/15/83	CVX-GF-212-085	D	85'	7.5	

* Where no depth is noted, sampling was from a set monitoring well. For depths of monitoring wells, see "First CLP Sampling" table.

Notes:

1. All samples taken with bailer after evacuation with pump unless otherwise noted.
2. RB is Rinse Water sample.

TABLE 2

SAMPLE IDENTIFICATION MATRIX
CHARLEVOIX, MICHIGAN
SOURCE IDENTIFICATION TASK
FIRST CLP SAMPLING

S.A.S. No. - 883S

Laboratory Service - California Analytical Lab

Sample No.	Date Sampled	Date Shipped	Airbill No.	Sample Tag No.	Chain of Custody No.
CVX-GL-001-1	12/20/83	12/21/83	454603155	5-47501/5-47502	5-10490
CVX-GL-002-1	12/21/83	12/22/83	454603166	5-47503/5-47504	5-10494
CVX-GL-003-1	12/20/83	12/21/83	454603155	5-47505/5-47506	5-10490
CVX-GL-004-1	12/21/83	12/22/83	454603166	5-47507/5-47508	5-10494/5-10495
CVX-GL-005-1	12/21/83	12/21/83	454603155	5-47509/5-47510	5-10491
CVX-GL-006-1	12/20/83	12/21/83	454603155	5-47511/5-47512	5-10490
CVX-GL-007-1	12/20/83	12/21/83	454603155	5-47513/5-47514	5-10490
CVX-GL-008-1	12/21/83	12/21/83	454603155	5-47515/5-47516	5-10491
CVX-GL-008-1D	12/21/83	12/21/83	454603155	5-47517/5-47518	5-10491
CVX-GL-011-1	12/20/83	12/21/83	454603155	5-47519/5-47520	5-10490
CVX-GL-101-1	12/21/83	12/21/83	454603155	5-47521/5-47522	5-10492
CVX-GL-102-1	12/21/83	12/22/83	454603166	5-47523/5-47524	5-10495
CVX-GL-103-1	----------	----------	----------	Not Sampled	----------
CVX-GL-104-1	12/21/83	12/22/83	454603166	5-47527/5-47528	5-10495
CVX-GL-105-1	12/21/83	12/21/83	454603155	5-47529/5-47530	5-10490
CVX-GL-106-1	12/21/83	12/21/83	454603155	5-47531/5-47532	5-10490
CVX-GL-201-1	12/21/83	12/21/83	454603155	5-47535/5-47536	5-10491
CVX-GL-201-1D	12/21/83	12/21/83	454603155	5-47533/5-47534	5-10490/5-10491
CVX-GL-202-1	12/21/83	12/21/83	454603155	5-47537/5-47538	5-10491
CVX-GL-206-1	12/21/83	12/22/83	454603166	5-47539/5-47540	5-10494
CVX-GL-209-1	12/21/83	12/21/83	454603155	5-47541/5-47542	5-10491
CVX-GL-210-1	12/21/83	12/21/83	454603155	5-47543/5-47544	5-10491
CVX-GL-212-1	12/21/83	12/22/83	454603166	5-47545/5-47546	5-10494
CVX-GL-212-1D	12/21/83	12/22/83	454603166	5-47547/5-47548	5-10494
CVX-GL-213-1	12/21/83	12/22/83	454603166	5-47556/5-47557	5-10494
CVX-GL-280-1	12/21/83	12/22/83	454603166	5-47555	5-10495
CVX-GL-291-1	12/21/83	12/22/83	454603166	5-47549/5-47550	5-10494
CVX-GL-293-1	12/21/83	12/22/83	454603166	5-47553/5-47554	5-10494

TABLE 3

FIELD DATA SUMMARY
CHARLEVOIX, MICHIGAN
SOURCE IDENTIFICATION TASK
FIRST CLP SAMPLING

Well No.	Date Sampled	Sample No.	USGS Top of Casing	Static Water Level	USGS Water Level	Depth of Well	Well Volume (gal)	Purge Volume (gal)
1	12/20/83	CVX-GL-001-1	643.35	30.12	613.23	46.0	2.7	27
2	12/21/83	CVX-GL-002-1	607.31	24.88	582.43	36.0	1.9	19
3	12/20/83	CVX-GL-003-1	641.16	54.65	586.51	68.0	2.2	23
4	12/21/83	CVX-GL-004-1	610.00	29.40	580.60	34.6	0.9	9
5	12/21/83	CVX-GL-005-1	628.80	49.56	579.24	56.5	1.2	12
6	12/20/83	CVX-GL-006-1	625.35	40.17	585.18	53.0	2.1	22
7	12/20/83	CVX-GL-007-1	620.43	22.27	598.16	37.0	2.5	25
8	12/21/83	CVX-GL-008-1	626.90	46.62	580.28	57.0	1.7	18
8D	12/21/83	CVX-GL-008-1D	626.90	46.62	580.28	57.0	1.7	18
11	12/20/83	CVX-GL-011-1	638.00	54.18	583.82	67.0	2.1	22
T1	12/21/83	CVX-GL-101-1	596.89	16.84	580.05	27.8	1.8	19
T2	12/21/83	CVX-GL-102-1	595.11	15.50	579.61	25.5	1.7	17
T3	----------	Not Sampled --	591.47	12.12	579.35	24.0	2.0	20
T4	12/21/83	CVX-GL-104-1	587.00	8.00	579.00	21.0	2.2	22
T5	12/21/83	CVX-GL-105-1	612.95	29.57	583.38	36.0	1.1	11
T6	12/21/83	CVX-GL-106-1	614.42	31.09	583.33	34.5	0.6	6
201	12/21/83	CVX-GL-201-1	615.66	34.56	581.10	51.5	2.8	29
201D	12/21/83	CVX-GL-201-1D	615.66	34.56	581.10	51.5	2.8	29
202	12/21/83	CVX-GL-202-1	613.30	31.95	581.35	68.5	6.1	61
206	12/21/83	CVX-GL-206-1	594.41	14.17	580.24	35.0	3.5	35*
209	12/20/83	CVX-GL-209-1	611.38	29.99	581.39	49.0	3.2	32
210	12/21/83	CVX-GL-210-1	609.12	28.50	580.62	49.0	3.4	35
212	12/21/83	CVX-GL-212-1	612.08	31.80	580.28	61.0	4.9	49
212D	12/21/83	CVX-GL-212-1D	612.08	31.80	580.28	61.0	4.9	49
213	12/21/83	CVX-GL-213-1	DNR Fisheries Well	---	---	---	---	---
280	12/21/83	CVX-GL-280-1	Rinse Drum	---	---	---	---	---
291	12/21/83	CVX-GL-291-1	Field Blank	---	---	---	---	---
293	12/21/83	CVX-GL-293-1	Field Blank	---	---	---	---	---

Note: Level D Protection used on all samples. *Water level data not used; measurement in error.

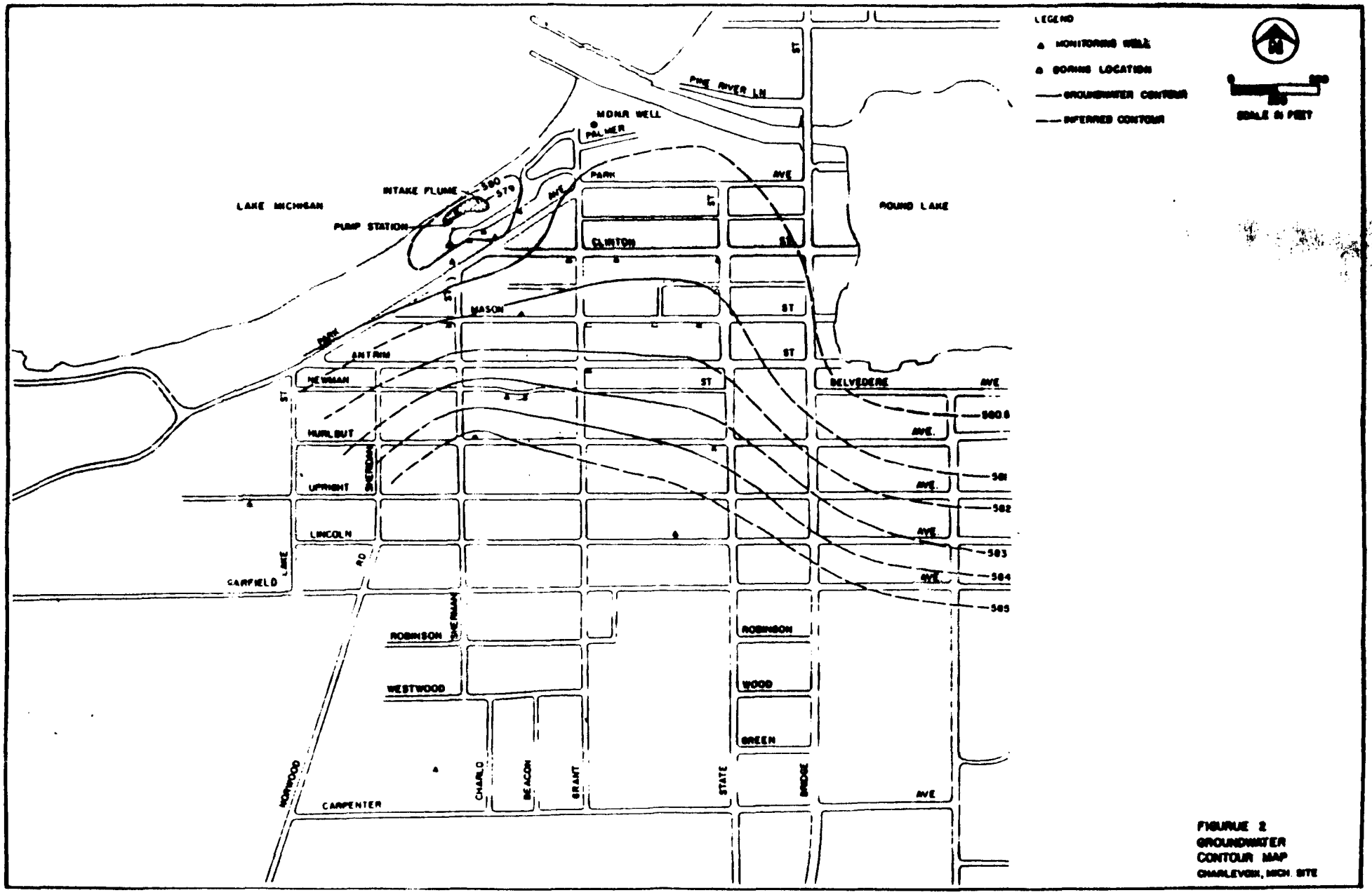


FIGURE 2
GROUNDWATER
CONTOUR MAP
CHARLEVOIX, MICH SITE

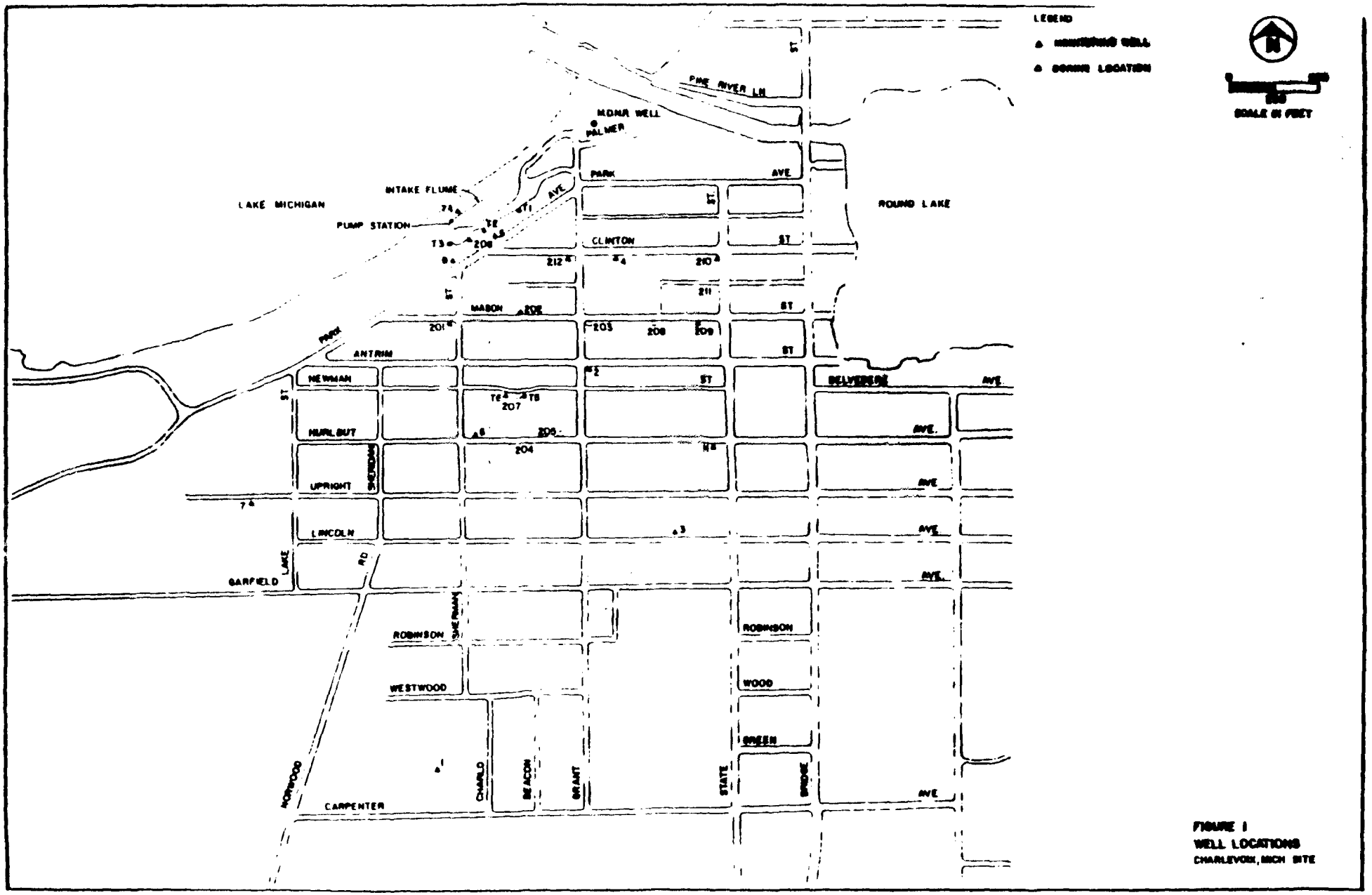


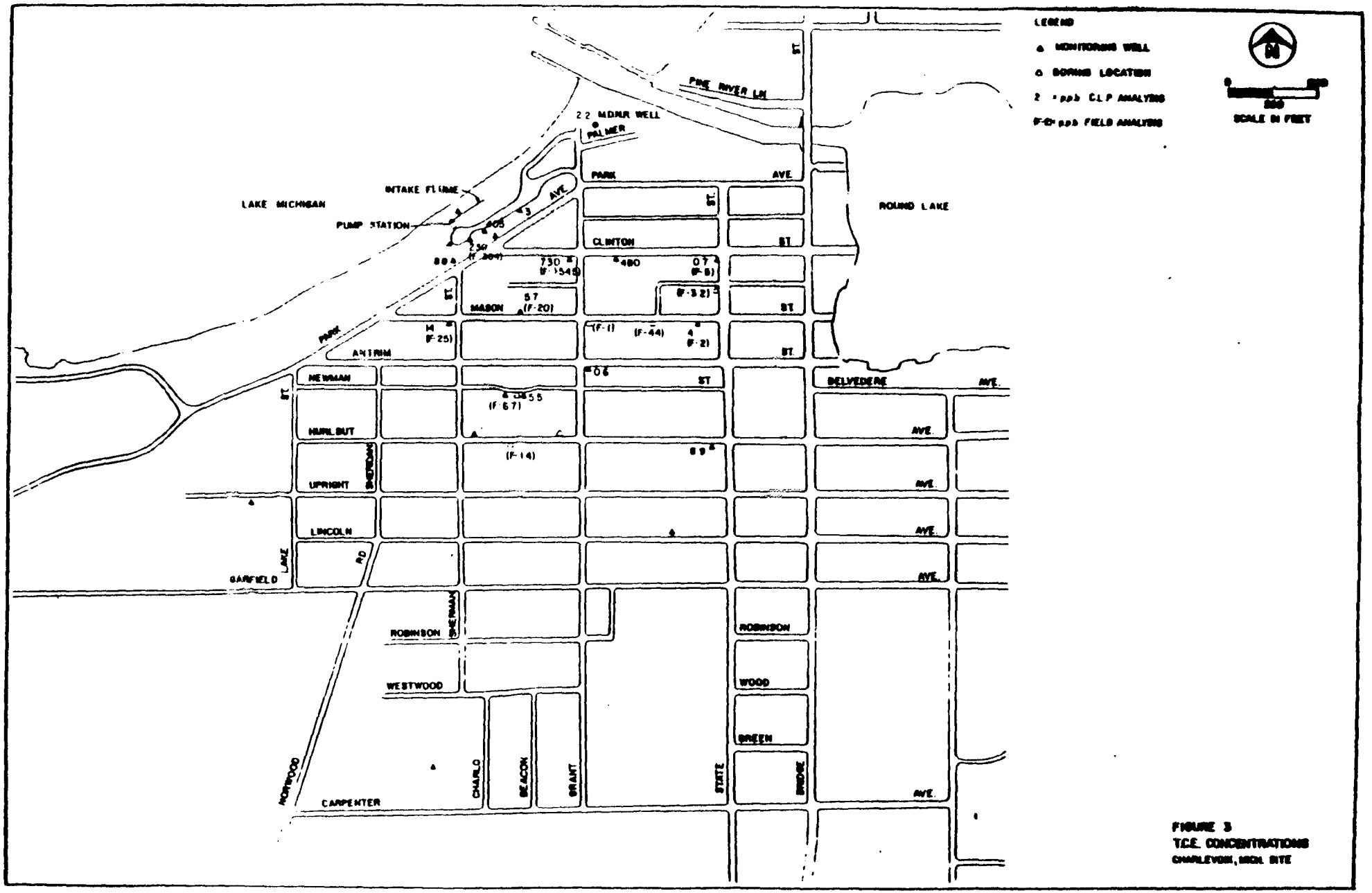
FIGURE 1
WELL LOCATIONS
CHARLEVOIX, MICH SITE

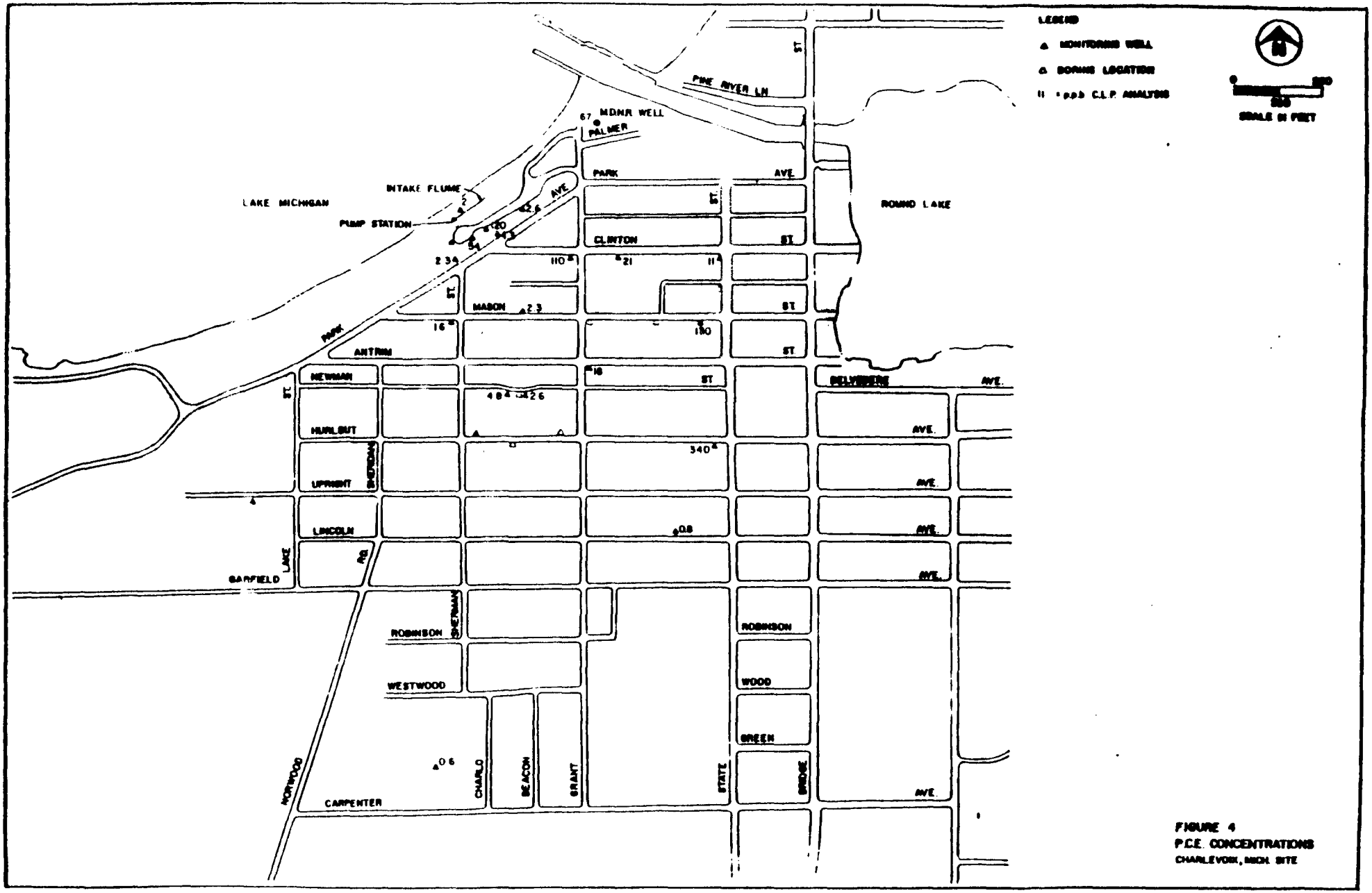
FIGURES

TABLE 4
SUMMARY OF ORGANIC ANALYSIS
CHARLEVOIX, MICHIGAN
SOURCE IDENTIFICATION TASK
FIRST CLP SAMPLING

Well No.	Trichloroethylene (ppb)	Tetrachloroethylene (ppb)
Method Blank	< 0.5	< 0.5
1	< 0.5	0.6
2	0.6	18
3	< 0.5	0.8
3D	< 0.5	0.6
Spike	4.7 (5.0)	0.7
4	480	21
5	< 0.5	4.3
6	< 0.5	< 0.5
6D	< 0.5	< 0.5
Spike	4.7 (5.0)	< 0.5
7	< 0.5	< 0.5
8	8.1	2.3
8D	8.8	1.7
11	8.9	340
T1	3.0	2.6
T2	405	< 20
T3	Not Taken	Not Taken
T4	< 0.5	2.0
T5	5.5	2.6
T6	< 0.5	4.8
201	14	1.6
201D	11	< 0.5
202	5.7	2.3
206	230	54
209	4.0	130
210	0.7	11
212	730	< 50
212D	660	110
DNR Well (213)	2.2	67
Rinse Water (280)	17	< 0.5
Field Blank (291)	< 0.5	1.7
Field Blank (292)	1.7	< 0.5

D = Duplicate


LEGEND
MONITORING WELL
BORING LOCATION
ppb C.L.P ANALYSIS
ppb FIELD ANALYSIS
SCALE IN FEET
LAKE MICHIGAN
INTAKE FLUME
PUMP STATION
PINE RIVER LN
22 MGNR WELL
PALMER
PARK AVE.
CLINTON ST.
MASON ST.
ANTRIM ST.
NEWMAN ST.
HALIBUT
UPRIGHT
LINCOLN
GARFIELD LAKE RD
ROBINSON
WESTWOOD
NORWOOD
CARPENTER
CHARLO
BEACON
GRANT
STATE
WOOD
GREEN
BRIDGE
ROUND LAKE
BELVEDERE AVE.
SHERMAN
FIGURE 3
T.C.E. CONCENTRATIONS
CHARLEVOIX, MICH. SITE


LEGEND
MONITORING WELL
BORING LOCATION
ppb C.L.P. ANALYSIS
SCALE IN FEET
LAKE MICHIGAN
INTAKE FLUME
PUMP STATION
MDNR WELL
PALMER
PINE RIVER LN
PARK
AVE.
ROUND LAKE
CLINTON
ST.
MASON
ANTRIM
NEWMAN
HURLBUT
UPRIGHT
SHERIDAN
LINCOLN
LAKE
RD.
GARFIELD
ROBINSON
SHERMAN
WESTWOOD
NORWOOD
CHARLO
BEACON
GRANT
CARPENTER
STATE
WOOD
GREEN
BRIDGE
BELVEDERE
FIGURE 4
P.C.E. CONCENTRATIONS
CHARLEVOIX, MICH. SITE

APPENDIX 1

DRILLING LOGS

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FORM-GMC-6-0

Page 1 of 4

LOG OF SOIL BORING NO. B#201

DATE 11-29-83

JOB NO. 83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows for 6"	Moisture %	Density lbs P.C.F.	Unc. Comp. Strength Psf.	Dry %
0'6"	TOPSOIL							
4'0"	Moist, medium, light brown SAND with traces of silt		1 2 3 4					
6'6"	Moist, medium, dark brown SAND with traces of silt		5 6					
12'0"	Moist, medium, light brown SAND with traces of silt		7 8 9 10 11 12					
22'0"	Moist, medium, light brown SAND with traces of gravels & silt		13 14 15 16 17 18 19 20 21 22					
	Moist, medium to coarse, brown SAND with little fine gravel and traces of silt		23 24 25					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT 37' FT. 6" INS.
G.W. AFTER COMPLETION 32' FT. 6.5" INS.
G.W. AFTER HRS. FT. INS.

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LOG OF SOIL BORING NO. 84201

DATE 11-29-83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Qu %
Moist, medium to coarse, brown SAND with little fine gravel and traces of silt		26					
		27					
		28					
		29					
		30					
		31					
		32					
		33					
		34					
		35					
		36					
		37					
		38					
		39					
		40					
		41					
		42					
		43					
		44					
		45					
		46					
		47					
		48					
		49					
		50					
		51					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#201

DATE 11-30-83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Rec. %
	Moist, medium to coarse, brown SAND with little fine gravel and traces of silt		52					
			53					
			54					
			55					
			56					
			57					
			58					
			59					
	Higher silt and fine SAND content than indicated on this log - Hole produced very little water after 60'. E3		60					
			61					
			62					
63'0"			63					
	Wet, coarse, brown SAND with little silt and gravel and traces of clay High silt and fine SAND content - E3		64					
			65					
			66					
			67					
			68					
			69					
			70					
			71					
			72					
			73					
			74					
			75					
			76					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With [illegible]

GROUND WATER OBSERVATIONS
G.W. ENCOUNTERED AT FT. HRS.
G.W. AFTER COMPLETION FT. HRS.
G.W. AFTER HRS. FT. HRS.

FORM-GMC-6-0

Page 4 of 4

GMC [illegible]

LOG OF [illegible] BORING NO. [illegible]

DATE [illegible]

JOB NO. [illegible] - Monitoring Wells

SURFACE [illegible]

Strata depth	Description	Depth (ft)
	[illegible], coarse, brown [illegible] with Traces [illegible] silt and gravel and [illegible] of clay. High Silt and [illegible] SAND content - [illegible]	77
		78
		79
		80
		81
		82
		83
		84
		85
86'0"		86
	END OF BORING	87
		88
		89
		90
		91
		92
		93
		94
		95
		96
		97
		98
		99
		100
		101
		102

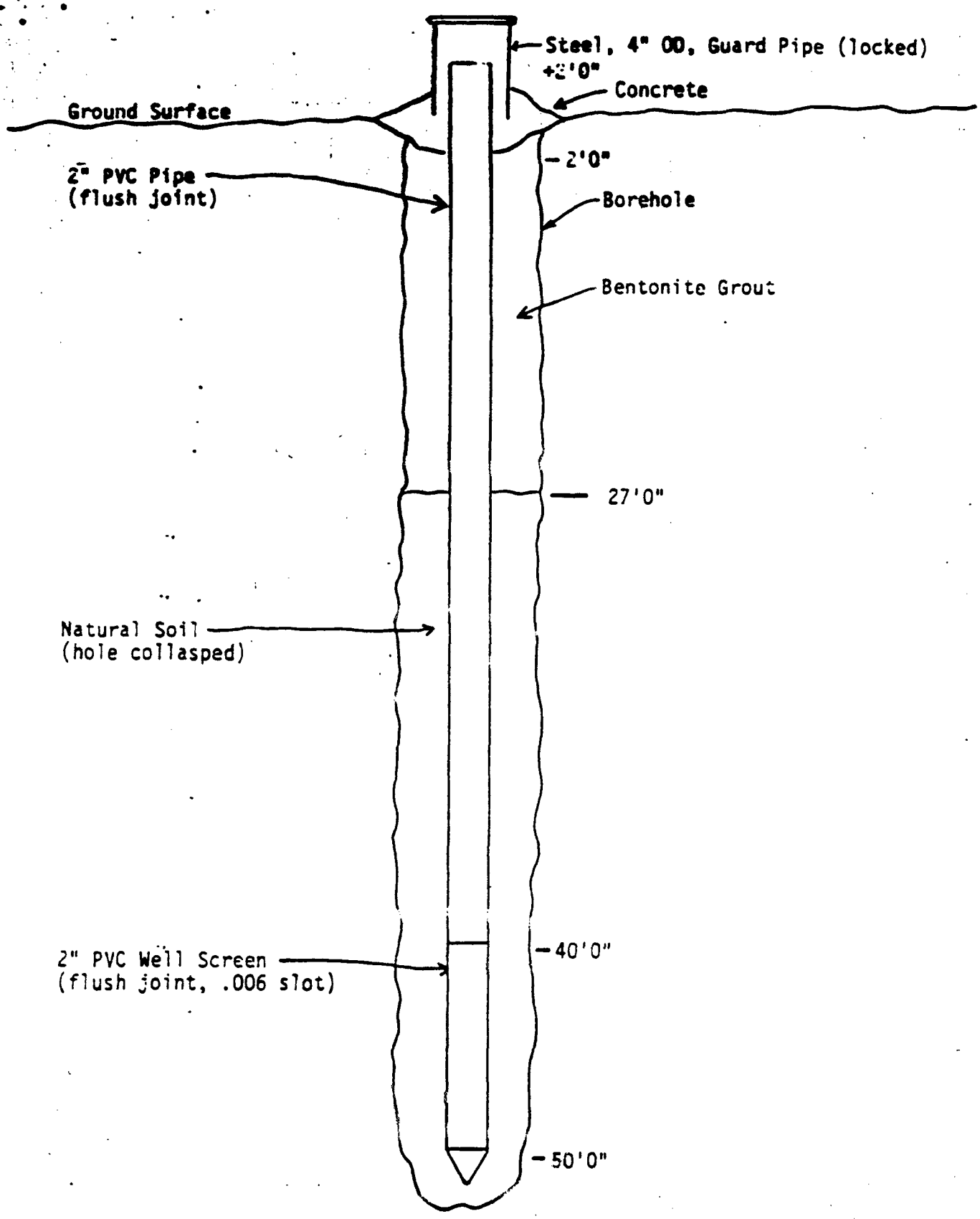
TYPE OF SAMPLE
D. - DISTURBED
U.L. - UNDIST. LINER
S.T. - SHELBY TUBE
S.S. - SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With [illegible] Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.



END OF BORING ACTUALLY 86'0"

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B#201 Sketch of Well Installation
Charlevoix Monitoring Wells
GMC Job No: HG-83015

N.T.S.

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LOG OF SOIL BORING NO. B#201A

DATE 12/8/83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Density WT. P.C.F.	Unc. Comp. Strength PSF.	Str. %
0'6"	TOPSOIL							
	Moist, medium, dark brown SAND with traces of silt		1					
			2					
			3					
			4					
			5					
			6					
			7					
8'0"			8					
	Moist, coarse, brown SAND with traces of fine gravel and silt		9					
			10					
			11					
			12					
			13					
			14					
15'0"			15					
	Moist, coarse, light brown SAND, with some gravel and traces of silt		16					
			17					
			18					
			19					
			20					
			21					
			22					
23'0"			23					
	Moist, coarse, brown SAND with some gravel and traces of silt		24					
			25					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS: Boring was redrilled because of broken plug. Hole caved from 32' - 93', grouted from 32' to surface

Standard Penetration Test - Driving 2" OD Sampler 1' With 140 # Hammer Falling 30": Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	37	FT.	0	INS.
G.W. AFTER COMPLETION	36	FT.	6	INS.
G.W. AFTER HRS.		FT.		INS.

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FORM-GMC-6-0
2 of 4

LOG OF SOIL BORING #
B#206
DATE 12/8/83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Dir. %
		26					
		27					
		28					
		29					
		30					
		31					
32'0"		32					
Wet, coarse, brown SAND with little gravel and traces of silt and clay		33					
		34					
		35					
		36					
		37					
		38					
		39					
		40					
		41					
		42					
		43					
		44					
		45					
		46					
		47					
		48					
		49					
		50					
		51					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	FT.	INS.
G.W. AFTER COMPLETION	FT.	INS.
G.W. AFTER HRS.	FT.	INS.

Geotechnical & Materials Consultants Inc.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#206

DATE 12/8/83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

SOIL DESCRIPTION	Samples & Type	Depth	Penetration Blows Per 6"	Moisture %	Density Wt. P.C.F.	Unc. Comp. Strength PSF.	Sieve %
Wet, coarse, brown SAND with little gravel and traces of silt and clay FORMATION FROM -60' TO 88 ft has high silt and fine SAND CONTENT - $\mathcal{L}^3$		52					
		53					
		54					
		55					
		56					
		57					
		58					
		59					
		60					
		61					
		62					
		63					
		64					
		65					
		66					
		67					
		68					
		69					
		70					
		71					
		72					
		73					
		74					
		75					
		76					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

LOG OF SOIL BORING B#206

DATE 12/8/83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Dry %
	Wet, coarse, brown SAND with little gravel and traces of silt and clay		77					
			78					
			79					
			80					
			81					
			82					
			83					
			84					
			85					
			86					
			87					
88'0"			88					
	Wet, brown CLAY with little silt and traces of sand		89					
			90					
			91					
			92					
93'0"			93					
	END OF BORING		94					
			95					
			96					
			97					
			98					
			99					
			100					
			101					
			102					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test – Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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Page 1 of 4

LOG OF SOIL BORING NO. B#202

DATE 12-3-83

JOB NO. HG-83015 ~ PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Dir. %
0'6"	TOPSOIL							
2'0"	Moist, medium, brown SAND with traces of silt and fine gravel		1					
			2					
4'0"	Moist, medium, dark brown SAND with traces of silt and fine gravel		3					
			4					
6'6"	Moist, medium, brown SAND with traces of silt and fine gravel		5					
			6					
17'0"	Moist, medium to coarse, brown SAND with traces of silt and fine gravel		7					
			8					
			9					
			10					
			11					
			12					
			13					
			14					
			15					
			16					
			17					
23'0"	Moist, medium to coarse, light brown SAND with traces of silt and gravel		18					
			19					
			20					
			21					
			22					
			23					
	Moist, coarse, brown SAND with little gravel and cobbles and traces of silt		24					
			25					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30": Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT 29' FT. 0" INS.
G.W. AFTER COMPLETION 29' FT. 6" INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

LOG OF SOIL BORING #

B#202

DATE 12-3-83

JOB NO. MG-8301S PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
29'0"			26					
			27					
			28					
			29					
	Wet, coarse, brown SAND with little gravel and cobbles and traces of silt		30					
			31					
			32					
			33					
			34					
			35					
			36					
37'0"			37					
	Wet, coarse, brown SAND with little gravel and traces of silt		38					
			39					
			40					
			41					
			42					
			43					
			44					
			45					
			46					
			47					
48'0"			48					
	Wet, coarse, brown SAND with some silt and gravel		49					
			50					
			51					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S.-SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#202

DATE 12-4-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows for 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
53'0"			52					
			53					
	Wet, coarse, brown SAND with some gravel and traces of cobbles and silt		54					
			55					
			56					
			57					
			58					
			59					
			60					
			61					
			62					
			63					
			64					
			65					
			66					
			67					
			68					
			69					
			70					
			71					
			72					
			73					
			74					
			75					
			76					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

GMC Associates, Inc.

FORM-GMC-6-0
Page 4 of 4

LOG OF SOIL BORING

B#202

DATE 12-4-83

JOB NO. 83-8301B PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample # Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	Wet, coarse, brown SAND with some gravel and traces of cobbles and silt		77					
			78					
			79					
			80					
			81					
			82					
			83					
	Increase content of fine sand and silt ≤3		84					
			85					
			86					
87'0"			87					
	Wet, brown CLAY with little silt and traces of fine gravel		88					
			89					
			90					
91'0"			91					
	END OF BORING		92					
			93					
			94					
			95					
			96					
			97					
			98					
			99					
			100					
			101					
			102					

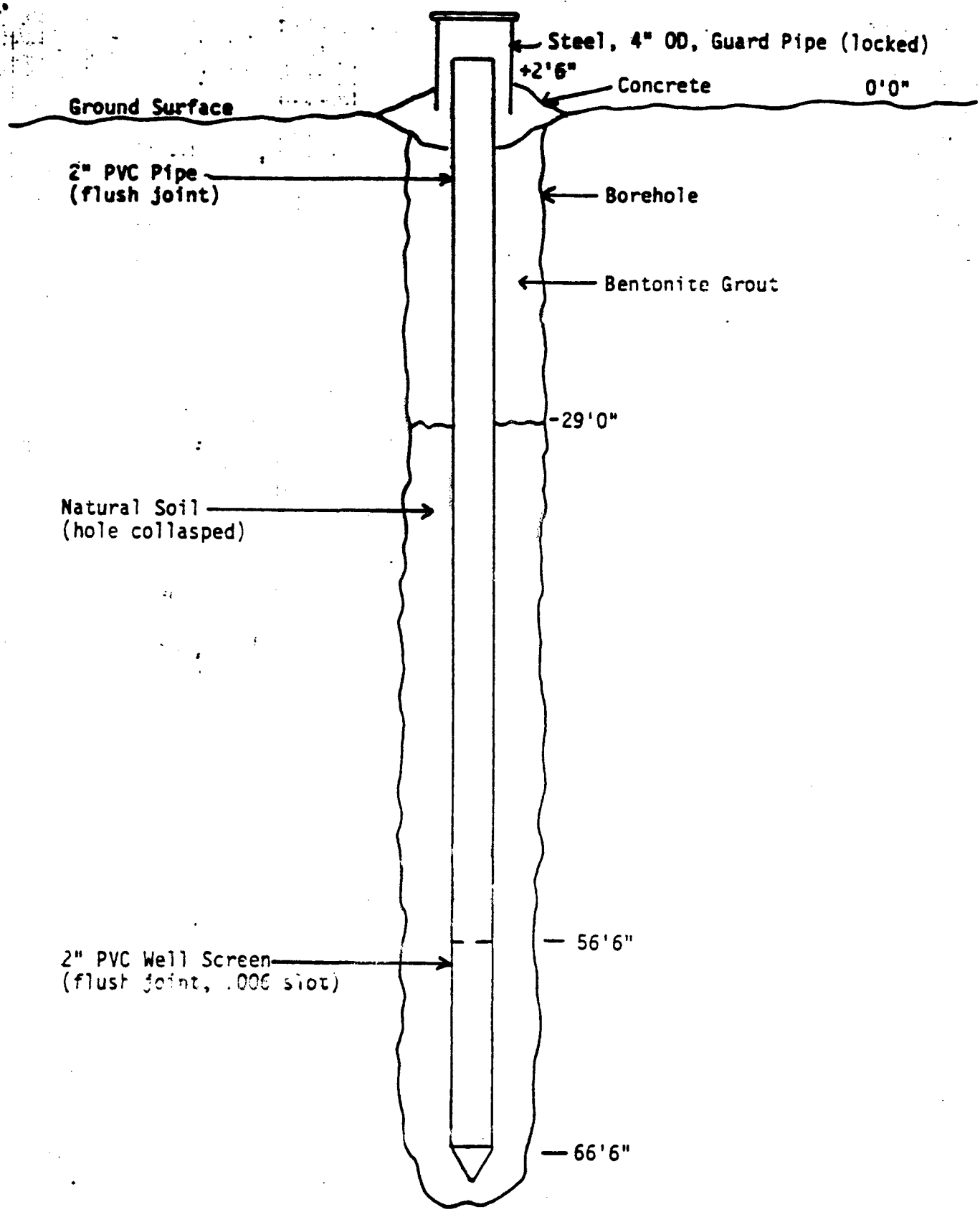
TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.



END OF BORING ACTUALLY 91'0"

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B#202 Sketch of Well Installation
Charlevoix Monitoring Wells
GMC Job No: HG-83015

N.T.S.

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LOG OF SOIL BORING NO. B#203

DATE 12-5-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
0'6"	TOPSOIL							
2'0"	Moist, medium, dark brown SAND with traces of silt and fine gravel		1					
			2					
4'6"	Moist, medium, brown SAND with traces of silt and fine gravel		3					
			4					
	Moist, medium, to coarse brown SAND with traces of fine gravel and silt		5					
			6					
			7					
			8					
			9					
			10					
			11					
			12					
			13					
			14					
			15					
			16					
			17					
			18					
			19					
			20					
			21					
			22					
			23					
			24					
			25					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS: Hole caved from 28'-88'.
Hole grouted from 28' to surface.

Standard Penetration Test – Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	28'	FT.	0"	INS.
G.W. AFTER COMPLETION	27'	FT.	0"	INS.
G.W. AFTER	HRS.	FT.		INS.

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FORM-GMC-6-0

LOG OF SOIL BORING: B#203

DATE 12-5-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Dry %
27'0"			26					
			27					
	Wet, medium to coarse, brown SAND with traces of gravel, cobbles, and silt		28					
			29					
			30					
			31					
			32					
			33					
			34					
			35					
			36					
			37					
			38					
			39					
			40					
			41					
			42					
43'0"			43					
	Wet, coarse, brown SAND with traces of gravel and silt		44					
			45					
			46					
			47					
			48					
			49					
			50					
			51					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#203

DATE 12-5-83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows for 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
Wet, coarse, brown SAND with traces of gravel and silt		52					
		53					
		54					
		55					
		56					
		57					
		58					
		59					
		60					
		61					
		62					
		63					
		64					
		65					
		66					
		67					
		68					
		69					
		70					
		71					
		72					
		73					
		74					
		75					
		76					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

LOG OF SOIL BORING

B#203

DATE 12-5-83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Graphic & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Sp. %
	Wet, coarse, brown SAND with traces of gravel and silt		77					
			78					
			79					
			80					
			81					
			82					
			83					
			84					
			85					
			86					
			87					
88'0"			88					
	END OF BORING		89					
			90					
			91					
			92					
			93					
			94					
			95					
			96					
			97					
			98					
			99					
			100					
			101					
			102					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test – Driving 2" OD Sampler 1' With 140# Hammer Falling 30": Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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Page 1 of 4

LOG OF SOIL BORING NO. B#204

DATE 12-6-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTIONS	Sample & Type	Depth	Penetration Blows for 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Dir. %
0'6"	TOPSOIL							
2'6"	Moist, coarse, light brown SAND with some gravel and cobbles and traces of silt		1					
			2					
			3					
			4					
6'0"	Moist, coarse, brown SAND with traces of fine gravel and silt		5					
			6					
			7					
			8					
			9					
			10					
12'0"	Moist, medium to coarse, brown SAND with traces of gravel and silt		11					
			12					
			13					
			14					
			15					
			16					
			17					
			18					
			19					
			20					
			21					
			22					
			23					
			24					
	Moist, coarse, brown SAND with little fine gravel and traces of silt		25					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS: Hole plugged with natural soil from 83' - 96', and then grouted to the surface.

Standard Penetration Test – Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	48'	FT.	0"	INS.
G.W. AFTER COMPLETION	47'	FT.	0"	INS.
G.W. AFTER	HRS.		FT.	INS.

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LOG OF SOIL BORING NO. B#204

DATE 12-6-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Dry %
	Moist, coarse, brown SAND with little fine gravel and traces of silt		26					
			27					
			28					
			29					
			30					
			31					
			32					
			33					
			34					
			35					
36'0"			36					
	Wet, coarse, brown SAND with some gravel and cobbles and traces of silt		37					
			38					
			39					
40'0"			40					
	Wet, medium to coarse, brown SAND with little fine gravel and traces of silt		41					
			42					
			43					
			44					
			45					
			46					
			47					
			48					
			49					
			50					
			51					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT		FT.	HRS.
G.W. AFTER COMPLETION		FT.	HRS.
G.W. AFTER	HRS.	FT.	HRS.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#204

DATE 12-6-83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows for 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
Wet, medium to coarse, brown SAND with little fine gravel and traces of silt		52					
		53					
		54					
		55					
		56					
		57					
		58					
		59					
		60					
		61					
		62					
		63					
		64					
		65					
		66					
		67					
68'0"		68					
Wet, fine to medium, brown SAND with little silt and traces of fine gravel FORMATION HAS MORE FINE SAND AND SILT THAN INDICATED HERE. ATTEMPTS TO GET SAMPLES SHOWED VERY SLOW DEVELOPMENT WITH SIGNIFICANT SAND AND SILT CONTENT IN PRODUCED WATER. - ES		69					
		70					
		71					
		72					
		73					
		74					
		75					
		76					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

LOG OF SOIL BORING

B#204

DATE 12-6-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Samples & Types	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	Wet, fine to medium, brown SAND with little silt and traces of fine gravel		77					
			78					
			79					
			80					
			81					
			82					
			83					
			84					
85'0"			85					
	Wet, brown CLAY with some silt and traces of fine gravel		86					
			87					
			88					
			89					
			90					
			91					
			92					
			93					
			94					
			95					
96'0"			96					
	END OF BORING		97					
			98					
			99					
			100					
			101					
			102					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#205

DATE 12-7-83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt P.C.F.	Unc. Comp. Strength PSF.	Str. %
0'6"	TOPSOIL							
	Moist, coarse brown SAND with some gravel and cobbles and traces of silt		1					
			2					
			3					
4'0"			4					
	Moist, medium to coarse, brown SAND with little fine gravel and traces of silt		5					
			6					
			7					
			8					
			9					
			10					
			11					
			12					
			13					
			14					
15'0"			15					
	Moist, coarse, brown SAND with little fine gravel and traces of silt		16					
			17					
			18					
			19					
			20					
			21					
			22					
			23					
			24					
			25					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS: Hole plugged with natural soil from 46' - 93'. Hole grouted from 46' to the surface.
Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	50'	FT.	0"	INS.
G.W. AFTER COMPLETION	49'	FT.	3"	INS.
G.W. AFTER	HRS.	FT.		INS.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#205

DATE 12-7-83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows for 6"	Moisture %	Density W. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	Moist, coarse, brown SAND with little fine gravel and traces of silt		26					
			27					
			28					
			29					
			30					
			31					
			32					
			33					
			34					
			35					
			36					
37'0"			37					
	Moist, medium, brown SAND with traces of silt and fine gravel		38					
			39					
			40					
			41					
			42					
			43					
			44					
			45					
			46					
			47					
			48					
			49					
			50					
			51					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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LOG OF SOIL BORING NO. B#205

DATE 12-5-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

SOIL DESCRIPTION	Sample Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
Moist, medium, brown SAND with traces of silt and fine gravel		52					
		53					
		54					
		55					
		56					
		57					
		58					
		59					
		60					
		61					
		62					
63'0"		63					
Wet, fine to medium, brown SAND with little silt and traces of fine gravel FORMATION APPEARS TO BE CLEAN - LITTLE SILT HAD EXCELLENT PRODUCTION DURING DEVELOPMENT - Σ^3		64					
		65					
		66					
		67					
		68					
		69					
		70					
		71					
		72					
73'0"		73					
Wet, medium to coarse, brown SAND with traces of fine gravel and silt		74					
		75					
		76					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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[illegible] - (313) [illegible]

FORM-GMC-6-0

LOG OF SOIL BORING NO. B#205

DATE 12-7-83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows for 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Dry %
	Wet, medium to coarse, brown SAND with traces of fine gravel and silt		77					
			78					
			79					
			80					
			81					
			82					
			83					
			84					
			85					
			86					
			87					
			88					
			89					
			90					
			91					
			92					
93'0"			93					
	END OF BORING		94					
			95					
			96					
			97					
			98					
			99					
			100					
			101					
			102					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test – Driving 2" OD Sampler 1" With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.

G.W. AFTER COMPLETION FT. INS.

G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

Page 1 of 4

LOG OF SOIL BORING NO. B#206

DATE 12/10/83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV. _____

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Dry Density P.C.F.	Unc. Comp. Strength Psf.	Qu. %
1'0"	TOPSOIL		1					
	Moist, medium to fine, gray SAND with traces of silt and fine gravel		2					
			3					
			4					
			5					
			6					
			7					
6'0"			8					
	Moist, fine to medium, dark brown SAND with traces of silt and fine gravel		9					
			10					
			11					
12'0"			12					
	Wet, fine to medium, light brown SAND with fine gravel and traces of silt		13					
			14					
			15					
			16					
			17					
			18					
			19					
			20					
			21					
			22					
23'0"			23					
	Wet, fine to medium, brown SAND with little gravel and traces of silt		24					
			25					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	12	FT.	6	INS.
G.W. AFTER COMPLETION	11	FT.	3	INS.
G.W. AFTER HRS.		FT.		INS.

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LOG OF SOIL BORING NO. B#206

DATE 12/10/83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Dir. %
Wet, fine to medium, brown SAND with little gravel and traces of silt		26					
		27					
		28					
		29					
		30					
		31					
		32					
		33					
		34					
		35					
		36					
		37					
		38					
		39					
		40					
		41					
		42					
43'0"		43					
Wet, coarse, brown SAND, with some gravel and little silt		44					
		45					
		46					
		47					
		48					
		49					
		50					
		51					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

Geotechnical & Materials Consultants, Inc.

1241 GOLDSMITH, PLYMOUTH, MICHIGAN 48170 • (313) 459-8660

FORM-GMC-6-0

LOG OF SOIL BORING NO. B#206

DATE 12/10/83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows for 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Dry %
53'0"			52					
			53					
	Wet, medium to coarse, brown SAND with some gravel and traces of silt		54					
			55					
			56					
			57					
			58					
			59					
			60					
			61					
			62					
			63					
			64					
			65					
			66					
			67					
			68					
			69					
			70					
			71					
			72					
			73					
			74					
			75					
			76					

FORMATION FROM ~70' to 90 feet has relatively high silt and fine SAND content. Produced v. little water during development

E3

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test – Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

LOG OF SOIL BORING #

B#206

DATE 12/10/83

JOB NO. HG-83015 PROJECT Charlevoix- Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Qu. %
			77					
			78					
			79					
			80					
			81					
			82					
			83					
			84					
			85					
			86					
			87					
			88					
			89					
90'0"			90					
	Wet, brown CLAY with little silt and traces of fine gravel		91					
			92					
93'0"			93					
	END OF BORING		94					
			95					
			96					
			97					
			98					
			99					
			100					
			101					
			102					

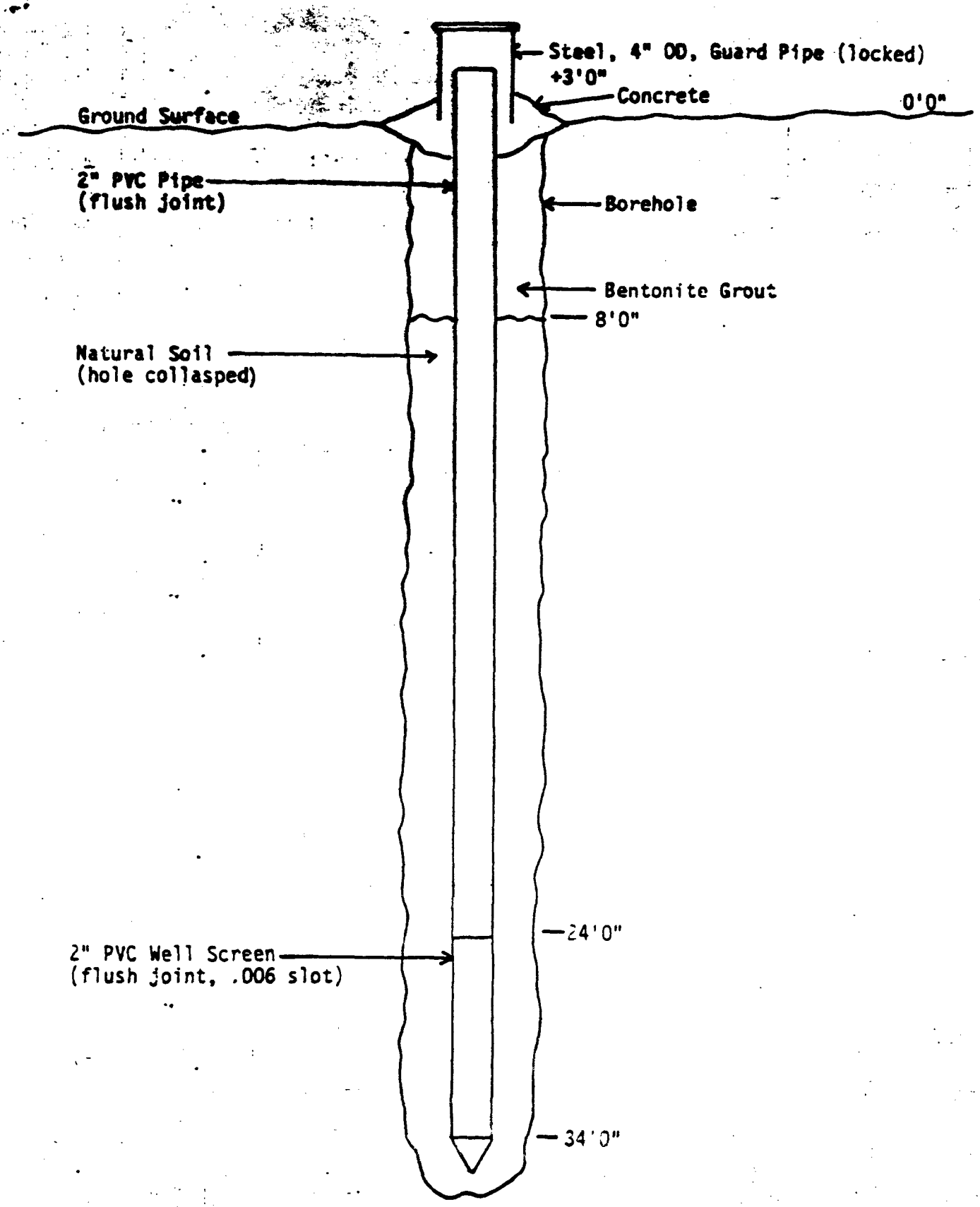
TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test – Driving 2" OD Sampler 1' With 140# Hammer Falling 30": Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. HRS.
G.W. AFTER COMPLETION FT. HRS.
G.W. AFTER HRS. FT. HRS.



END OF BORING ACTUALLY 93'0"

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B#206 Sketch of Well Installation
Charlevoix Monitoring Wells
GMC Job No: HG-83015

N.T.S.

GMC Associates, Inc.
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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#207

DATE 12/11/83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt P.C.F.	Unc. Comp. Strength PSF.	Dry %
1'0"	TOPSOIL		1					
	Moist, medium, brown SAND, with some gravel and cobbles and traces of silt		2					
			3					
4'0"			4					
	Moist, medium, dark brown SAND with traces of silt and fine gravel		5					
6'0"			6					
	Moist, medium, brown SAND with traces of fine gravel and silt		7					
			8					
			9					
			10					
			11					
			12					
			13					
			14					
			15					
			16					
			17					
			18					
			19					
			20					
			21					
22'0"			22					
	Moist, medium to coarse, brown SAND with little fine gravel and traces of silt		23					
			24					
			25					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS: Hole caved from 28' to 77.5'
Hole grouted from 0' - 28'

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	31	FT.	0	INS.
G.W. AFTER COMPLETION	30	FT.	0	INS.
G.W. AFTER HRS.		FT.		INS.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#207

DATE 12/11/83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
		26					
Moist, medium to coarse, brown SAND with little fine gravel and traces of silt		27					
		28					
		29					
		30					
		31					
		32					
		33					
		34					
		35					
		36					
		37					
		38					
		39					
40'0"		40					
Wet, medium to coarse, brown SAND with fine to medium gravel and traces of silt		41					
		42					
		43					
		44					
		45					
		46					
		47					
		48					
		49					
		50					
		51					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test – Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

Geotechnical & Materials Consultants, Inc.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#207

DATE 12/11/83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV. _____

51'0"	SOIL DESCRIPTION	Samples & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	Wet, medium to coarse, brown SAND and fine GRAVELS with traces of silt		52					
			53					
			54					
			55					
			56					
			57					
			58					
			59					
			60					
			61					
			62					
			63					
			64					
	J.W.S REPORTED CLAY, SANDY at 64 ft		65					
	E3		66					
67'0"			67					
	Wet, brown CLAY with some silt and traces of fine gravel		68					
			69					
			70					
			71					
			72					
			73					
			74					
			75					
			76					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

LOG OF SOIL BORING

B#207

DATE 12/11/83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
77'6"			77					
	END OF BORING		78					
			79					
			80					
			81					
			82					
			83					
			84					
			85					
			86					
			87					
			88					
			89					
			90					
			91					
			92					
			93					
			94					
			95					
			96					
			97					
			98					
			99					
			100					
			101					
			102					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#208

DATE 12-12-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Density lbs P.C.F.	Unc. Comp. Strength PSF.	Rec. %
1'8"	TOPSOIL		1					
4'0"	Moist, fine to medium, dark brown SAND with traces of silt.		2 3 4					
6'0"	Moist, fine to medium, light brown SAND with traces of silt		5 6					
8'0"	Moist, fine to medium, brown SAND with traces of silt		7 8					
17'0"	Moist, fine to medium, brown SAND with traces of fine gravel and silt		9 10 11 12 13 14 15 16 17					
22'0"	Moist, fine to medium, brown SAND with traces of fine gravel and silt		18 19 20 21 22					
25'6"	Moist, fine to medium, brown SAND with little gravel and cobbles and traces of silt		23 24 25					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS: Hole caved from 80' - 93'. Hole grouted from 63' - 80'. Caved again from 28' - 63' and then (cont'd grouted from 28' to the surface.

Standard Penetration Test – Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	28'	FT. 6"	INS.
G.W. AFTER COMPLETION	27'	FT. 3"	INS.
G.W. AFTER HRS.		FT.	INS.

GMC Associates Inc.

FORM-GMC-6-0

Page 2 of 4

LOG OF SOIL BORING NO. B#208

DATE 12-12-83

JOB NO. 86-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

SOIL DESCRIPTIONS	Graphic & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.S.F.	Unc. Comp. Strength PSF.	Qu. %
Wet, fine to medium, brown SAND with traces of fine gravel and silt		26					
		27					
		28					
		29					
Fine-grained sand and silt reported in developed water ℄		30					
		31					
		32					
		33					
		34					
		35					
		36					
		37					
		38					
		39					
		40					
		41					
		42					
Good production, clean formation has less silt + fine SAND ℄		43					
		44					
		45					
		46					
47'0"		47					
Wet, medium to coarse, brown SAND with traces of fine gravel and silt		48					
		49					
		50					
		51					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30". Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#208

DATE 12-12-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows for 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	Wet, medium to coarse, brown SAND with traces of fine gravel and silt		52					
			53					
			54					
			55					
			56					
			57					
			58					
			59					
			60					
			61					
			62					
			63					
			64					
			65					
			66					
			67					
			68					
69'0"			69					
	Wet, brown CLAY with little silt and traces of fine gravel		70					
			71					
72'0"			72					
	Wet, medium to coarse, brown SAND with traces of fine gravel and silt much higher content of fine than reported silt and clay content significant! CB		73					
			74					
			75					
			76					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test – Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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[illegible] NORTHVILLE, MI 48167 • [illegible]

FORM-GMC-6-0

LOG OF SOIL BORING NO. B#208

DATE 12-12-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows for 6"	Moisture %	Density WT. P.C.F.	Unc. Comp. Strength PSF.	Qu %
	Wet, medium to coarse, brown SAND with traces of fine gravel and silt		77					
			78					
			79					
			80					
			81					
			82					
			83					
			84					
			85					
			86					
			87					
			88					
			89					
			90					
			91					
			92					
93'0"			93					
	END OF BORING		94					
			95					
			96					
			97					
			98					
			99					
			100					
			101					
			102					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test – Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#209

DATE 12/13/83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows for 6"	Moisture %	Natural Dry Density P.C.F.	Unc. Comp. Strength PSF.	Str. %
1'0"	TOPSOIL		1					
	Moist, fine to medium, dark brown SAND with traces of silt		2					
			3					
4'0"			4					
	Moist, fine to medium, light brown SAND with traces of silt and fine gravel		5					
			6					
			7					
			8					
			9					
			10					
			11					
			12					
			13					
			14					
			15					
			16					
			17					
			18					
			19					
			20					
			21					
			22					
			23					
24'0"			24					
	Moist, fine to medium, brown SAND with cobbles & traces of silt		25					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#209

DATE 12/13/83

JOB NO. GM-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
			26					
27'0"			27					
	Wet, fine to medium, brown SAND with traces of fine gravel and silt		28					
			29					
			30					
			31					
			32					
			33					
			34					
			35					
			36					
37'6"			37					
	Wet, medium to coarse, brown SAND with little fine grave. and traces of silt		38					
			39					
			40					
			41					
			42					
			43					
			44					
			45					
			46					
47'0"			47					
	Wet, fine to medium, brown SAND with traces of fine gravel and silt		48					
			49					
			50					
			51					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test – Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

Geotechnical & Materials Consultants Inc.

FORM-GMC-6-0

Page 3 of 3

LOG OF SOIL BORING NO. B#209

DATE 12/13/83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Material Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	Wet, fine to medium, brown SAND with traces of fine gravel and silt		52					
			53					
			54					
			55					
			56					
			57					
			58					
			59					
60'0"			60					
	Wet, medium to coarse, brown SAND with traces of fine gravel and silt		61					
			62					
			63					
			64					
			65					
			66					
			67					
			68					
			69					
			70					
71'0"			71					
	Wet, gray CLAY with traces of silt		72					
73'0"			73					
	Wet, coarse, brown SAND with some gravel and traces of silt JWS reported clay-rich mtls to bottom of boring.		74					
			75					
			76					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

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FORM-GMC-6-0

Page 4 of 4

LOG OF SOIL BORING B#209

DATE 12/13/83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	Wet, coarse, brown SAND, with some fine gravel and traces of silt		77					
			78					
			79					
			80					
			81					
			82					
83'0"			83					
	END OF BORING		84					
			85					
			86					
			87					
			88					
			89					
			90					
			91					
			92					
			93					
			94					
			95					
			96					
			97					
			98					
			99					
			100					
			101					
			102					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

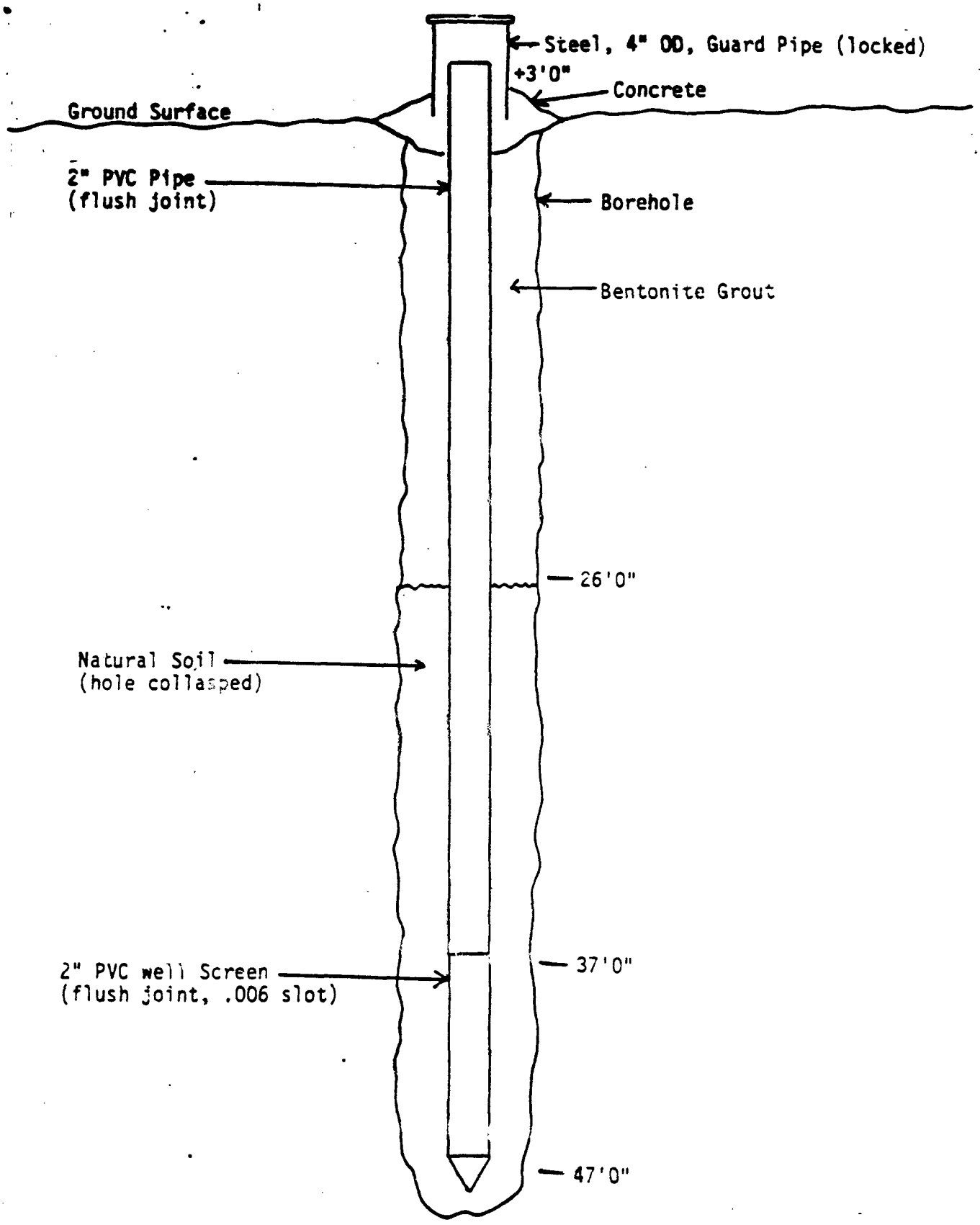
Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.

G.W. AFTER COMPLETION FT. INS.

G.W. AFTER HRS. FT. INS.



END OF BORING ACTUALLY 83'0"

B#209

Sketch of Well Installation
Charlevoix Monitoring Wells
GMC Job No: HG-83015

N.T.S.

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FORM-GMC-6-0

Page 1 of 4

LOG OF SOIL BORING NO. B#210

DATE 12/14/83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows for 6"	Moisture %	Density lbs P.C.F.	Unc. Comp. Strength PSF.	Str. %
1'0"	TOPSOIL		1					
	Moist, fine to medium, dark brown SAND, with traces of silt		2					
			3					
4'0"			4					
	Moist, fine to medium, light brown SAND, with traces of silt		5					
			6					
			7					
			8					
			9					
			10					
			11					
12'0"			12					
	Moist, fine, brown SAND with some silt and little clay		13					
14'0"			14					
			15					
			16					
			17					
			18					
			19					
			20					
			21					
			22					
			23					
			24					
			25					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

GMC Associates Inc.
ENGINEERS • SCIENTISTS • ECONOMISTS • MANAGERS
[illegible] NORTHVILLE, MI 48167 • (313) 348-[illegible]

FORM-GMC-6-0

LOG OF SOIL BORING #
B#210
DATE 12/14/83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Graphic & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
27'0"			26					
			27					
	Wet, fine, brown SAND and SILT		28					
			29					
30'0"			30					
	Wet, fine to medium, brown SAND with little silt		31					
			32					
			33					
			34					
			35					
			36					
			37					
			38					
			39					
			40					
			41					
			42					
			43					
			44					
			45					
			46					
			47					
			48					
			49					
			50					
			51					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
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REMARKS:

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GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

Addendum
TASK TECHNICAL MEMORANDUM

TO: Bruce Cutright, CH2M-Hill

FROM: Rick Burke, Snell Environmental Group, Inc.
Ed Everett, Keck Consulting Services, Inc.

SUBJECT: Charlevoix, Michigan Remedial Investigation
Task 2 - Source Identification Program
Hydraulic Conductivity Testing

JOB NO.: W65253.0

INTRODUCTION

The March 27, 1984 Task Technical Memorandum outlined the work to be done to determine the hydraulic conductivity of the water-table aquifer in the area of the soil borings done during December, 1983. This work was done on April 16 and 17, 1984.

The work activities herein were performed in partial satisfaction of BOA SC-5-023, Work Assignment No. 46-5283.0, RI Task 2.

1.0 FIELD HYDRAULIC CONDUCTIVITY TESTING

1.1 Purpose

The purpose of running these tests was to determine the permeability of the aquifer for predicting flow rates and potential purge volumes.

1.2 Scope

The outline in the Task Technical Memorandum called for testing 10 to 12 wells including all "200" series wells and selected other wells within the area of contamination.

1.3 General Procedure

In-situ hydraulic conductivity tests can be conducted (on small diameter wells) by injection or extraction of a known volume of water and then measuring the change in head toward equilibrium over time. During the planning stages of this work, it was determined that injection of water into the well would be undesirable due to possible effects on future water quality analyses. Extraction of a known volume of water was also judged to be undesirable if it involved pumping the water onto the ground also this is a difficult procedure to accomplish.

The proposed method was to use a displacement technique, where a tube (sealed) of known volume would be lowered into the well to displace water. When the tube is installed in the well, the water level rises and then returns to original level and upon pulling the tube (after reaching equilibrium) the water level will recover back to original static water level. The specific procedure is outlined below:

1. Set a pressure transducer at the bottom of the well or 20 feet into water.

2. Allow the transducer to stabilize (temperature dependent), pull the transducer to above the water level and check for zero reading, adjusting as necessary.

3. Put displacement tube (one gallon volume displacement) into well and lower quickly into the water.

4. Record transducer reading prior to displacing water and start recording readings when tube is in place.

5. Record decline in water level until equilibrium is reached.

6. Rapidly pull tube from well.

7. Record readings during recovery of water level until equilibrium is reached.

8. Clean all equipment with TSP solution and rinse with water from the Township supply.

1.4 Personnel

The project team consisted of Keck Consulting Services, Inc. (KCS) personnel - Ed Everett and Jeff Pincumbe. Prior to starting the work, we met with Mr. Larry Levengood, District 3 Health Department to discuss the work and get keys for all the wells,

1.5 Field Work Chronology

All work was conducted in level D protection with Nitrile gloves used to handle all equipment.

April 16, 1984, Monday

KCS personnel arrived in Charlevoix at approximately 8:30 a.m. and met with Mr. Levengood to get keys. The weather was snow, windy and approximately 30°F.

Water levels were measured in all accessible wells prior to starting any of the hydraulic conductivity tests.

The order of testing was determined to proceed from wells of low or no contamination into the areas of higher contamination. The order was: 201, 203, 210, 209, 5, 206, T2, 4 and 212, for a total of 9 wells. Table 1 summarizes the results of this work.

Well 201 was attempted first. We found that the well casing was not straight and we were only able to get the tube partially into the water. Because we had to work to get the tube down, we were unable to measure the decline in water level (which was occurring as fast as we could install the tube). Recovery occurred in this well within 3 seconds of pulling the tube.

In well 203, we could not get the tube down into the water because of the well construction. Well 210 had been struck by a car or plow, bending the casing guard and the well casing. The surface seal was not broken. We were unable to get the tube in this well.

We altered the order to get well 209 while we were near that site. Again we had difficulty with getting the tube installed in the well and lost the initial measurements. Upon extracting the tube, the water level recovered within 3 seconds.

This was the last attempted sample on this day. E. Everett left Charlevoix and J. Pincumbe stayed to complete the testing.

April 17, 1984, Tuesday

E. Everett called R. Burke to discuss the results of previous day's sampling. It was decided to attempt to run tests on wells 4, 206 and T2 and if they were not successful, to cease the testing.

J. Pincumbe conducted the tests on this rainy, 34° day.

At well 4, the well casing was crooked and the tube could not be lowered into the well. The same conditions existed at well 206.

The testing was completed on well T2 with the results showing recovery in less than 5 seconds.

J. Pincumbe called E. Everett and it was decided to cancel the testing.

J. Pincumbe left the site at 10:00 a.m.

1.6 Data Summary

Table 1 shows the results of the field hydraulic conductivity testing.

Table 2 shows the water level readings taken on April 16, 1984. A groundwater contour map is included as Figure 1.

2.0 GROUNDWATER FLOW PATTERN

Figure 1 shows the groundwater elevations that were made from the April 16, 1984 data. There are no significant differences seen between these data and that originally shown in the Task Technical Memorandum.

3.0 ANALYSES OF HYDRAULIC CONDUCTIVITY TESTS

The tests conducted were unsuccessful for two reasons; 1) many wells were crooked or bent which did not allow getting the displacement tube into the water and even where the tube could enter the water it could not be forced to sufficient depth, and 2) the aquifer is highly permeable and recovery rates were so rapid that only one reading could be taken, and even the accuracy of that reading was marginal.

The information does indicate that the permeability of the aquifer is over 150 GPD/ft^2 as originally estimated in the Task Technical Memorandum. The monitor wells are screened in the zones of highest permeability where there is no contamination, and the zones which are contaminated are within this highly permeable material.

The methodology used to attempt measuring hydraulic conductivities was inappropriate based on the findings during the testing. Injection of water into the wells may be possible, however, one would have to have large volumes available to do the tests and the effect on water quality would detract from this technique.

One accurate method of determining the permeability would be to install a 4-inch well (or larger) with nearby observation wells and run an aquifer test. The cost and timing would be justified if purging of the aquifer were considered as a viable remedial measure.

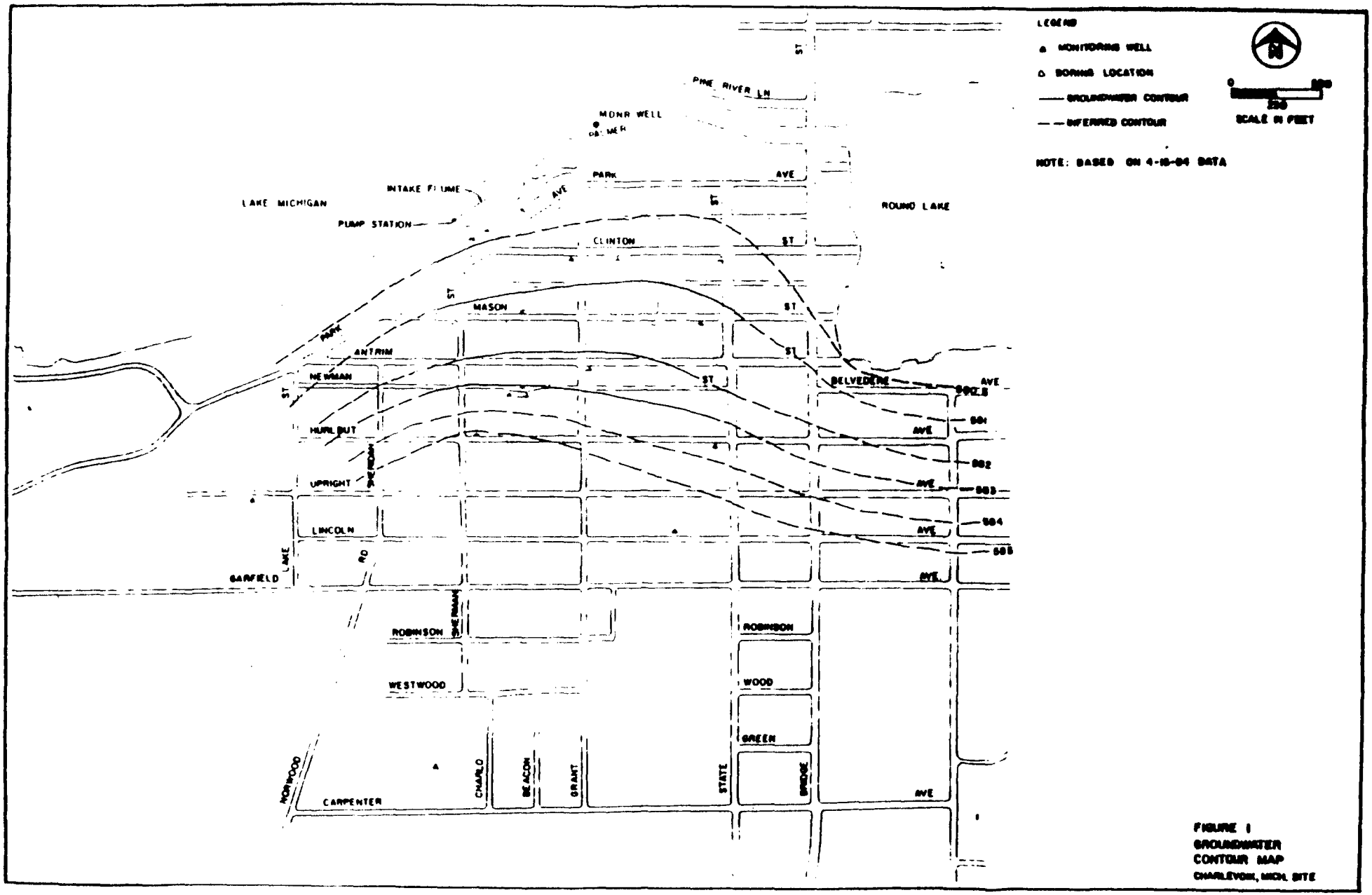
Table 1
Field Data Summary
Hydraulic Conductivity Testing
Charlevoix, Michigan Remedial Investigation

Well No.	Date	Pressure Transducer Readings* Start	End	Time	Notes
201	4/16/84	13.6	16.4	3 sec.	well crooked
203	4/16/84				could not get probe into water
210	4/16/84				well guard & casing bent
209	4/16/84	12.8	16.2	3 sec.	well crooked
5					not tested
206	4/17/84				could not get probe into well
T2	4/17/84	10.2	13.6	5 sec.	well crooked
4	4/17/84				could not get probe in well
212					not tested

*start readings are those taken immediately upon withdrawing tubes and end radings are static water levels as measured prior to installing tube

Table 2
Field Data Summary
Water Level Elevations
Charlevoix, Michigan

Well No.	Date Measured	U.S.G.S. Top of Casing	Static Water Level	U.S.G.S. Water Level
1	4/16/84	643.35	16.48	626.87
2	4/16/84	607.31	24.94	582.37
4	4/16/84	610.00	29.29	580.71
5	4/16/84	628.80	48.36	580.44
6	4/16/84	625.35	40.19	585.16
7	4/16/84	620.43	20.96	599.47
8	4/16/84	626.90	46.36	580.54
11	4/16/84	638.00	54.02	583.98
T2	4/16/84	595.11	14.73	580.38
T6	4/16/84	614.42	31.15	583.27
201	4/16/84	615.66	34.54	581.12
202	4/16/84	613.30	32.10	581.20
206	4/16/84	594.41	14.04	580.37
209	4/16/84	611.38	30.00	581.38
210	4/16/84	609.12	28.52	580.60
212	4/16/84	612.08	31.34	580.74


LEGEND
MONITORING WELL
BORING LOCATION
GROUNDWATER CONTOUR
INFERRED CONTOUR
SCALE IN FEET
NOTE: BASED ON 4-15-84 DATA
PINE RIVER LN
MDNR WELL
PARK AVE
INTAKE FLUME
LAKE MICHIGAN
PUMP STATION
ROUND LAKE
CLINTON ST
MASON ST
ANTRIM ST
NEWMAN ST
BELVEDERE AVE
HURLBUT ST
UPRIGHT ST
LINCOLN ST
GARFIELD RD
LAKE
SHERMAN
ROBINSON
WESTWOOD
WOOD
GREEN
NORTHWOOD
CHARLO
BEACON
GRANT
STATE
BRIDGE
CARPENTER AVE
FIGURE 1
GROUNDWATER
CONTOUR MAP
CHARLEVOIX, MICH. SITE

CH2M HILL

TECHNICAL MEMORANDUM

TO: File

FROM: Isaac Johnson
Bruce Cutright

DATE: August 21, 1984

PROJECT: W65253.00

RE: Charlevoix Remedial Investigation
Phase II Field Activities

INTRODUCTION

The Phase II field activities consisted of four major efforts:

- A second round of groundwater sampling and water level measurements
- A field inspection of buildings
- A shallow soil boring program
- A deep soil boring and additional monitoring well installation program

The Phase II field activities were conducted from July 11 through July 27, 1984. These activities were performed in partial satisfaction of Work Assignment No. 46-5L83.0.

GROUNDWATER SAMPLING AND WATER LEVEL MEASUREMENTS

Objective

The purpose of the second round of groundwater sampling was to gather data on trichloroethene (TCE) and perchloroethene (PCE), or tetrachloroethene, concentrations and water levels at existing monitoring wells associated with the Charlevoix site, shown in Figure 1. An additional objective of this task was to determine variations in groundwater quality and water levels from previous sampling efforts.

Scope

The scope of the second round of groundwater sampling included the following:

- Water level measurements in 21 monitoring wells.
- Groundwater samples collected from 19 monitoring wells.
- Three duplicate samples and two blank samples.

All samples were analyzed for volatile organics at California Analytical Laboratories, Sacramento, California. All samples were also screened for TCE and PCE in the field using a Photovac GC unit.

Personnel and Procedures

The existing monitoring wells were sampled from July 11 through July 13, 1984. The following personnel were involved with the sampling effort:

Ed Everett - Keck Consulting Services
Jeff Pincumbe - Keck Consulting Services
Robert Hunt - Snell Environmental Group

Water levels were measured in all wells prior to sampling, using an electric sounder. All measurements were taken from the top of well casing. The electric sounder and cable were decontaminated between each well using a solution of tri-sodium phosphate (TSP) and Charlevoix Township water, followed by a rinse of Charlevoix Township water.

Monitoring wells were purged by pumping five bore volumes of water using the Johnson-Keck Model SP-81 submersible pump. Samples were then collected using a Teflon bailer to fill three 40-ml volatile organic analysis (VOA) vials. Two vials from each well were packed in iced coolers according to U.S. EPA Contract Laboratory Program (CLP) protocol and shipped via Federal Express to California Analytical Laboratories, Sacramento, California, on the day the samples were collected. The third vial collected at each well was placed in a separate iced cooler for screening with a Photovac GC unit the week of July 16, 1984.

Decontamination procedures included two steps to avoid contamination of the sample and well and to minimize the possibility of cross-contaminating wells. Solutions were used in sequence to decontaminate sampling equipment. Trisodium phosphate (TSP) (1 cup of TSP per 30 gallons of water) was used as a

decontamination solution. This was followed by a clean water rinse. All water used in the decontamination and rinse solutions was obtained from Charlevoix Township.

The pump was decontaminated by pumping TSP solution for 5 minutes followed by 5 minutes of pumping the clean water rinse solution. All decontamination solutions were discharged at the City of Charlevoix wastewater treatment plant the end of each working day.

A Photovac, portable gas chromatograph (GC), unit was set up in the Charlevoix County Annex Building basement on July 16, 1984. It was operated by Phil Campagna of Ecology and Environment, Inc., to screen samples collected from existing monitoring wells and samples collected from additional borings and wells for TCE and PCE.

Data Summary

A summary of the sample tracking documentation for the groundwater samples sent to the contract lab is given in Table 1. Static water levels and Photovac screening results for TCE and PCE are given in Table 2. A groundwater contour map for July 1984 is presented in Figure 1. Contract Laboratory analytical results are presented in Table 3.

FIELD INSPECTION

Objectives

The purpose of the field inspection was to attempt to identify the presence of organic vapors in buildings, crawl spaces, and storm drains in the suspected plume areas. A secondary objective of the field inspection was to search for potential sources of TCE and PCE contamination.

Scope

The field inspection was conducted using an HNU PI-101 photoionizing organic vapor analyzer calibrated to benzene, at the beginning of each work day. The relative response, for both TCE and PCE vapors, is approximately equal to 90 percent of the response for benzene on the HNU.

The inspection, conducted in and around the 10 buildings listed in Table 4, consisted of walking through the buildings

carrying the HNU unit and surveying basements, crawl spaces, walls, corners, floors, and floor drains.

Personnel

The field inspection was conducted on Monday, July 16, 1984, and Thursday, July 19, 1984.

On Monday, July 16, the inspection covered public buildings, B.J. Goodwin's (formerly Art's Drycleaners) and the Newman Street Dump. On Thursday, July 19, private buildings along the alley east of the middle school and the funeral home were inspected. The personnel involved with the inspection each day were:

July 16, 1984	July 19, 1984
Isaac Johnson/CH2M HILL	Jack Kratzmeyer/U.S. EPA
Aaron Sussel/Snell Envir. Group	Aaron Sussel
Larry Levengood/District Health Dept. No. 3	Larry Levengood

Data Summary

A summary of the field inspection activities is presented in Table 4.

SHALLOW SOIL BORINGS

Objective

The purpose of the shallow soil borings was to collect soil samples in the unsaturated zone and groundwater samples from the zone just below the water table to identify the source of TCE and possibly PCE contamination.

Scope

Twelve shallow borings were drilled to approximately 5 feet below the water table at the locations shown in Figure 2.

Fifty-two soil samples and 12 groundwater samples were analyzed for TCE and PCE using headspace analysis with the Photovac unit.

Personnel and Methods

The shallow soil boring activity was conducted from July 17 through July 20, 1984.

The following personnel were involved with the shallow soil borings:

Isaac Johnson, CH2M HILL - Field Team Leader/Site Safety Officer
Aaron Sussel, Snell Environmental Group - Sampling Technician
Phil Campagna, Ecology & Environment - Photovac Operator
Tom Skipper, Keck Consulting Services - Driller
Jeff Pincumbe, Keck Consulting Services - Driller

Shallow soil boring locations were chosen based upon previous data from the existing wells. Initial locations were selected to intersect the areas of highest known TCE concentrations. As borings were completed and groundwater samples screened for TCE and PCE with the Photovac, additional locations were selected in areas expected to be closer to the source of TCE contamination.

The borings were advanced using a Mobil Prospector drill rig mounted on a small garden tractor and 3-inch-diameter, solid-stem continuous flight augers. Soil samples were collected using standard split spoons and a 140-pound drop hammer. Groundwater samples were collected by driving a 2-inch-diameter, 2-foot-long, stainless steel well point screen and 2-inch-diameter galvanized pipes to a depth approximately 5 feet below the water table. The Johnson-Keck Model SP-81 pump was used to purge the galvanized pipe for 10 minutes and the sample was taken with a 2-inch Teflon bailer. Sample vials were then placed in an iced cooler until they could be analyzed using the Photovac.

The split spoons and the pump were decontaminated between samples using a TSP solution and a clean water rinse. The augers and drill rig were steam cleaned between each boring.

Field Data Summary

Boring logs for the shallow borings are included in Attachment A (to be added at a later date). A summary of static water levels, groundwater sample depths, and Photovac results for groundwater samples is shown in Table 5. No TCE or PCE was detected using headspace analysis on any of the soil samples collected in the shallow borings.

DEEP SCREENED AUGER BORINGS AND ADDITIONAL MONITORING WELL INSTALLATIONS

Objective

The purpose of the deep borings and additional monitoring wells was to further assess the extent of the TCE and possibly the PCE plumes. Secondary objectives of this effort were to assess the highest concentrations of TCE at or near the source, determine the width of the plume, and install additional wells for groundwater elevation measurements.

Scope

The scope of work involved installing five additional wells in eight additional borings (Figure 2.) Four wells (315, 316, 317, and 320) were installed using 3¼-inch-diameter hollow stem augers. One well (319) and the other three borings (313, 314 and 318) were advanced using a 3¼-inch-diameter screened hollow stem auger. In these borings water samples were collected as the borings were advanced, to obtain concentration data with depth.

Personnel and Methods

The deep screened borings and additional monitoring wells were installed July 23 through July 27, 1984. The following personnel were involved with this effort:

Isaac Johnson/CH2M HILL
Robert Hunt/Snell Environmental Group
Harjit Sidhu/GMC Drilling
John Simmer/GMC Drilling
Dave Paholak/GMC Drilling

GMC, Inc., of Northville, Michigan, provided a Mobile B-52 truck-mounted drill rig and a three-man crew. The boring and well locations were selected based upon previous data

from the existing wells and the shallow borings, completed the preceding week. The boreholes for borings 313, 314, 318 and 319 were advanced with 3¼-inch I.D. hollow stem augers, with the lead auger screened. Auger cuttings were examined by the drill crew and the hydrogeologist. Groundwater samples were collected at the intervals listed in Table 6. The procedure for groundwater sampling was as follows:

- The augers were air developed at the selected interval to remove sand and silt from the screened section.
- Five (5) casting volumes of water were pumped from the augers with the Keck SP-81 sampling pump at a rate of approximately 1 gpm.
- Groundwater samples were collected using both the Keck SP-81 pump and a 2-inch stainless bailer or as noted in Table 6.
- Samples were taken in VOA vials and transported to the Photovac unit for analysis of TCE and PCE concentrations.
- The air line, sampling pump, and bailer were decontaminated between samples using a TSP solution and a clean water rinse.
- One monitoring well was installed in a screened auger boring (319) for groundwater elevation measurements. The other four monitoring wells were installed using conventional 3¼-inch I.D. hollow stem augers. The well locations were chosen to confirm the areas of high TCE concentrations and for groundwater level measurements. The wells were developed and sampled using the same procedure as for the borings. The drill rig, augers and tools were steam cleaned between each boring.

Field Data Summary

Boring logs and well construction sheets are included in Attachment A (to be added at a later date). A summary of sample depths and Photovac results is shown in Table 6.

Table 1
SAMPLE IDENTIFICATION MATRIX
SECOND CONTRACT LABORATORY PROGRAM SAMPLING ROUND
CHARLEVOIX, MICHIGAN RI

Sample Number	Date Sampled	Date Shipped	Airbill Number	Sample Tag Number	Chain of Custody Number
CVX-GL-206-2	07/11/84	07/11/84	473500160	5-51366/5-51367	5-9210
CVX-GL-104-2	07/11/84	07/11/84	473500160	5-51368/5-51369	5-9210
CVX-GL-102-2	07/11/84	07/11/84	473500160	5-51370/5-51371	5-9210
CVX-GL-005-2	07/11/84	07/11/84	473500160	5-51372/5-51373	5-9210
CVX-GL-008-2	07/11/84	07/11/84	473500160	5-51374/5-51375	5-9210
CVX-GL-008-2D	07/11/84	07/11/84	473500160	5-51378/5-51379	5-9210
CVX-GL-291-2	07/11/84	07/11/84	473500160	5-51376/5-51377	5-9210
CVX-GL-001-2	07/12/84	07/12/84	473500171	5-51380/5-51381	5-9211
CVX-GL-003-2	07/12/84	07/12/84	473500171	5-51382/5-51383	5-9211
CVX-GL-007-2	07/12/84	07/12/84	473500171	5-51384/5-51385	5-9211
CVX-GL-006-2	07/12/84	07/12/84	473500171	5-51386/5-51387	5-9211
CVX-GL-011-2	07/12/84	07/12/84	473500171	5-51388/5-51389	5-9211
CVX-GL-011-2D	07/12/84	07/12/84	473500171	5-51390/5-51391	5-9211
CVX-GL-105-2	07/12/84	07/12/84	473500171	5-51392/5-51393	5-9211
CVX-GL-106-2	07/12/84	07/12/84	473500171	5-51394/5-51395	5-9212
CVX-GL-002-2	07/12/84	07/12/84	473500171	5-51396/5-51397	5-9212
CVX-GL-201-2	07/12/84	07/12/84	473500171	5-51398/5-51399	5-9212
CVX-GL-202-2	07/12/84	07/12/84	473500171	5-51400/5-51401	5-9212
CVX-GL-202-2D	07/12/84	07/12/84	473500171	5-51412/5-51413	5-9212
CVX-GL-209-2	07/12/84	07/12/84	473500171	5-51402/5-51403	5-9212
CVX-GL-210-2	07/12/84	07/12/84	473500171	5-51404/3051405	5-9212
CVX-GL-292-1	07/12/84	07/12/84	473500171	5-51410/5-51411	5-9213
CVX-GL-004-2	07/13/84	07/13/84	615271554	5-51406/5-51407	5-9214
CVX-GL-212-2	07/13/84	07/13/84	615271554	5-51408/5-51409	5-9214
CVX-GL-212-2D	07/13/84	07/13/84	615271554	5-51414/5-51415	5-9214
CVX-GL-292-2	07/13/84	07/13/84	615271554	5-51416/5-51417	5-9214

Note:

Case No. 1171E
All samples sent to California Analytical Laboratories

GLT441/73

Table 2
FIELD GROUNDWATER DATA SUMMARY
SECOND CLP SAMPLING ROUND
CHARLEVOIX, MICHIGAN RI

Well Number	Date Sampled	Sample of Number	Well Depth (ft)	Static Water Level: Feet Below Top of Casing	Static Water Level: Elevation M.S.L.	Sampling Method	Trichloroethene-TCE (Concentration-ug/L)	Tetrachloroethene or Perchloroethene-PCE (Concentration-ug/L)	Comments
1	7/12/84	CVI-GF-001-2	46.0	29.86	613.49	Bailed	1	*	
2	7/12/84	CVI-GF-002-2	36.0	14.54	592.77	Bailed	*	1.5	
3	7/12/84	CVI-GF-003-2	68.0	54.38	586.78	Bailed	*	*	
4	7/13/84	CVI-GF-004-2	34.6	28.71	581.29	Bailed	344	*	
5	7/11/84	CVI-GF-005-2	56.5	48.07	580.73	Bailed	*	*	
6	7/12/84	CVI-GF-006-2	53.0	39.92	585.43	Bailed	*	*	
7	7/12/84	CVI-GF-007-2	37.0	21.58	598.85	Bailed	*	*	
8	7/11/84	CVI-GF-008-2	57.0	46.08	580.82	Bailed	8	*	
11	7/12/84	CVI-GF-011-2	67.0	53.75	584.25	Bailed	8	194	
11	7/12/84	CVI-GF-011-2D	67.0	53.75	584.25	Bailed	8	194	Field duplicate
T1	7/11/84	--	27.8	15.84	583.05	-	-	-	Not sampled
T2	7/11/84	CVI-GF-102-2	25.5	14.54	580.57	Bailed	65	*	
T3	-	--	24.0	-	-	-	-	-	Not sampled-well casing bent
T4	7/11/84	CVI-GF-104-2	21.0	6.79	580.21	Bailed	*	*	
T5	7/12/84	CVI-GF-105-2	36.0	29.28	583.67	Bailed	1	*	
T6	7/12/84	CVI-GF-106-2	34.5	30.78	583.64	Bailed	*	*	
201	7/12/84	CVI-GF-201-2	51.5	34.04	581.62	Bailed	23	*	
202	7/12/84	CVI-GF-202-2	68.5	31.48	581.82	Bailed	15	*	
202	7/12/84	CVI-GF-202-2D	68.5	31.48	581.82	Bailed	10	*	Field duplicate
206	7/11/84	CVI-GF-206-2	35.0	14.00	580.41	Bailed	200	*	
209	7/12/84	CVI-GF-209-2	49.0	29.41	581.97	Bailed	3	119	
210	7/12/84	CVI-GF-210-2	49.0	27.84	581.28	Bailed	3	25	
212	7/13/84	CVI-GF-212-2	61.0	30.86	581.22	Bailed	422	*	
212	7/13/84	CVI-GF-212-2D	61.0	30.86	581.22	Bailed	406	*	Field duplicate
-	7/11/84	CVI-GF-291-2	-	-	-	Bailed	*	*	Field blank
-	7/12/84	CVI-GF-292-2	-	-	-	Bailed	*	*	Field blank

*Not detected

GLT441/75

Table 3
SECOND CONTRACT LABORATORY PROGRAM SAMPLING ROUND
GROUNDWATER ANALYSIS
CHARLEVOIX, MICHIGAN RI

Well Number	Laboratory Sample Number	Trichloroethene (TCE)	Tetrachloroethene or Perchloroethene (PCE)	Comments
CVX-GL-001-2	1171ES07	*	*	
CVX-GL-002-2	1171ES14	*	16	
CVX-GL-003-2	1171ES08	*	*	
CVX-GL-004-2	1171ES19	960	5.5	
CVX-GL-005-2	1171ES04	*	*	
CVX-GL-006-2	1171ES10	*	*	
CVX-GL-007-2	1171ES09	*	*	
CVX-GL-008-2	1171ES05	10	*	
CVX-GL-008-2D	1171ED05	10	*	
CVX-GL-011-2	1171ES11	44	880	Trans-1,2-dichloro-ethene-5K
CVX-GL-011-2D	1171ED11	15	1,30[illegible]	
CVX-GL-102-2	1171ES03	140	*	
CVX-GL-104-2	1171ES02	*	*	
CVX-GL-105-2	1171ES12	*	*	
CVX-GL-106-2	1171ES13	*	*	
CVX-GL-201-2	1171ES15	25	*	
CVX-GL-202-2	1171ES16	13	*	
CVX-GL-202-2D	1171ED16	12	*	
CVX-GL-206-2	1171ES01	-	-	Results not received-8/21/84
CVX-GL-209-2	1171ES17	5K	150	
CVX-GL-210-2	1171ES18	*	35	Acetone 9.8 ug/L
CVX-GL-212-2	1171ES20	510	*	
CVX-GL-212-2D	1171ED20	580	*	
CVX-GL-291-2	1171ER06	*	*	Acetone 69 ug/L
CVX-GL-292-1	1171ER21	*	*	Acetone 47 ug/L
CVX-GL-292-2	1171ER22	*	*	

*Not detected above limits
All concentrations are expressed in ug/l.
'K' - indicates compounds detected at approximately the detection limit.

GLT441/74

Table 4
FIELD INSPECTION SUMMARY
CHARLEVOIX, MICHIGAN RI

Building or Location	Address	Date and Time Surveyed	Areas Surveyed	HNu Readings ppm-Equivalent to Benzene	Comments
County Annex Building	203 Antrim St.	7/16/84-0900	Outside of building in yard	0.6	Background reading
			Basement		
			- bathroom ceiling	2.2	
			- utility closet	1.2	
			- Building Inspection Offices		
			- ceiling	2.2	
			- northeast office	3.0	
			- north room	2.0	
			- record storage room	0.5	
County Building	Antrim St.	7/16/84-0930	Outside of building in yard	0.2	Background reading
			Basement		
			- hall next to vaults	0.0	
			- boiler room workshop	0.4	
			- furnace room	0.2	
City Hall and Fire Station	Mason St.	7/16/84-0945	Basement		
			- east storage room	0.5-1.0	
			- Police storage room	6.0-12.0	Room poorly ventilated with several gasoline containers
			- outside of Police storage room	1.0	
			- crawl space near stairway	0.5	
			- women's lounge	0.5	
B.J. Goodwin's (formerly Art's Drycleaners)	230 Antrim St.	7/16/84-1020	Basement		
			- along walls	0.5-0.8	
			Back storage room		
			- general area	0.5	
			- 6-inch drain	300	Drains formerly used for dry-cleanings
			- small drains along west wall	10-120	No longer being used
			Back shed		
			- along dirt floor	0.5	
			Outside along edge of buildings	3.0-7.5	
Newman St. Dump Site	Newman St.	7/16/84-1110	Well T5	0.0	
			Surface soil around site	0.0	

CLT441/76-1

Table 4 (continued)

Building or Location	Address	Date and Time Surveyed	Areas Surveyed	HNu Readings ppm-Equivalent to Benzene	Comments
Charlevoix Middle School	Grant St.	7/16/84-1330	West Wing		
			- northwest corner crawlspace	0.3	4-feet below floor level
			northwest corner crawlspace	0.3	Crawlspaces all very dry and dusty
			East Wing		
			north wall crawlspace	0.4	
			Basement		
			boiler room and laundry room	0.3	
			cleaning equipment storage room	1.0	Slight cleaning solvent odor
			- floor drain near north entrance to basement	0.3	
			Outside		
			fuel oil tank vent	0.3	
			- playground storm sewer in the track infield	0.0-0.2	
			- monitoring Well No. 4	0.0	
			monitoring Well No. 212	0.0	
Winchester's Funeral Home	State St.	7/19/84-1600	Basement		
			- general area, walls, floors	0.0	
			Garage		
			- general area	0.0	
			- floor drain	3.5	
Jack Gordon Residence	206 Clinton St.	7/19/84-1630	Metal garage behind house	0.0	
Rick Bienas Residence	204 Clinton St.	7/19/84-1645	Basement of house	0.0	
Mrs. Barry Wood Residence	207 Mason St.	7/19/84-1700	Basement and crawlspace of house	0.0	
	202 Clinton St.	7/19/84-1715	Shed and barn behind house	0.0	

GLT441/76-2

Table 5
SHALLOW BORING FIELD GROUNDWATER DATA SUMMARY
CHARLEVOIX, MICHIGAN RI

Boring Number	Date Sampled	Sample Number	Sample Depth	Groundwater Level (Feet Below Ground Surface	Sampling Method	Trichloroethene-TCE (concentration-ug/L)	Tetrachloroethene or Perchloroethene-PCE (concentration-ug/L)
301	7/17/84	CVX-GF-301-030	30'	28.0	Bail	194	*
302	7/17/84	CVX-GF-302-033	33'	30.5	Bail	1	*
303	7/18/84	CVX-GF-303-033	33'	26.5	Bail	3	66
304	7/18/84	CVX-GF-304-033	33'	25.6	Bail	2	1
305	7/18/84	CVX-GF-305-033	33'	27.0	Bail	14	2
306	7/18/84	CVX-GF-306-033	33'	27.2	Bail	*	22
307	7/19/84	CVX-GF-307-033	33'	27.5	Bail	*	*
308	7/19/84	CVX-GF-308-033	33'	28.2	Bail	922	8
309	7/19/84	CVX-GF-309-033	33'	25.3	Bail	5	6
309	7/19/84	CVX-GF-309-033D	33'	25.3	Bail	5	5
310	7/19/84	CVX-GF-310-033	33'	27.3	Bail	2	51
311	7/22/84	CVX-GF-311-033	33'	29.1	Bail	192	6
312	7/20/84	CVX-GF-312-033	33'	27.4	Bail	225	14

*Not detected

GLT441/77

Table 6
NEW WELLS AND DEEP BORINGS FIELD GROUNDWATER DATA SUMMARY
CHARLEVOIX, MICHIGAN RI

Boring/ Well Number	Date Sampled	Sample Number	Sample Depth	Sampling Method	Trichloroethene-TCE (concentration-ug/L)	Tetrachloroethene or Perchloroethene-PCE (concentration-ug/L)	Comments
313	7/23/84	CVX-GF-313-030A	30'	Pump	61	4	
313	7/23/84	CVX-GF-313-030B	30'	Pump	67	4	With van engine running
313	7/23/84	CVX-GF-313-030C	30'	Bail	59	3	With van engine off
314	7/24/84	CVX-GF-314-040A	40'	Pump	*	*	
314	7/24/84	CVX-GF-314-040B	40'	Pump	*	*	
314	7/24/84	CVX-GF-314-040C	40'	Bail	*	*	
314	7/24/84	CVX-GF-314-050A	50'	Pump	111	*	
314	7/24/84	CVX-GF-314-050B	50'	Pump	128	*	
314	7/24/84	CVX-GF-314-050C	50'	Bail	18	*	
314	7/24/84	CVX-GF-314-060A	60'	Pump	175	*	
314	7/24/84	CVX-GF-314-060B	60'	Pump	150	*	
314	7/24/84	CVX-GF-314-060C	60'	Bail	178	*	
315	7/25/84	CVX-GF-315-725A	37'	Pump	643	*	Well installed 7/24/84
315	7/25/84	CVX-GF-315-725B	37'	Pump	679	*	
315	7/25/84	CVX-GF-315-725C	37'	Bail	554	*	
315	7/25/84	CVX-GF-315-725CD	37'	Bail	589	*	
315	7/25/84	CVX-GF-315-725BD	37'	Pump	732	*	
315	7/25/84	CVX-GF-315-RB1	-	Pump	3	*	Rinse water blank
315	7/25/84	CVX-GF-315-RB2	-	Pump	1	*	Rinse water blank
315	7/25/84	CVX-GF-315-RB3	-	Pump	13	*	Rinse water blank
315	7/25/84	CVX-GF-315-RB4	-	Pump	1	*	Rinse water blank
315	7/25/84	CVX-GF-315-RB5	-	Pump	*	*	Rinse water blank
315	7/25/84	CVX-GF-315-RB6	-	Pump	2	*	Rinse water blank
315	7/25/84	CVX-GF-315-RB7	-	Pump	*	*	Rinse water blank
316	7/26/84	CVX-GF-316-726A	39'	Pump	*	18	Well installed 7/25/84
316	7/26/84	CVX-GF-316-726B	39'	Bailed	*	14	
316	7/26/84	CVX-GF-316-726C	39'	Pump	*	14	
316	7/26/84	CVX-GF-316-726AD	39'	Pump	*	19	
317	7/26/84	CVX-GF-317-726A	38'	Pump	2	25	Well installed 7/25/84
317	7/26/84	CVX-GF-317-726B	38'	Pump	1	28	
317	7/26/84	CVX-GF-317-726C	38'	Bail	2	25	
317	7/26/84	CVX-GF-317-RB1	-	Pump	*	*	Rinse water blank
318	7/26/84	CVX-GF-318-47A	47'	Pump	405		

*Not detected

GLT441/78-1

Table 6 (continued)

Boring/ Well Number	Date Sampled	Sample Number	Sample Depth	Sampling Method	Trichloroethene-TCE (concentration-ug/L)	Tetrachloroethene or Perchloroethene-PCE (concentration-ug/L)	Comments
318	7/26/84	CVX-GW-318-47B	47'	Pump	519	*	
318	7/26/84	CVX-GW-318-47C	47'	Bail	519	*	
318	7/26/84	CVX-GW-318-RB1	-	Pump	*	*	Rinse water blank
318	7/26/84	CVX-GW-318-RB2	-	Pump	*	*	Rinse water blank
318	7/26/84	CVX-GW-318-RB3	-	Pump	*	*	Rinse water blank
318	7/26/84	CVX-GW-318-62A	62'	Pump	456	*	Rinse water blank
318	7/26/84	CVX-GW-318-62B	62'	Pump	476	*	Rinse water blank
318	7/26/84	CVX-GW-318-62C	62'	Bail	344	*	Rinse water blank
318	7/26/84	CVX-GW-318-62AD	62'	Pump	420	*	Rinse water blank
318	7/26/84	CVX-GW-318-62BD	62'	Pump	440	*	Rinse water blank
318	7/26/84	CVX-GW-318-62CD	62'	Bail	211	*	Rinse water blank
319	7/26/84	CVX-GW-319-47A	47'	Pump	25	9	Rinse water blank
319	7/26/84	CVX-GW-319-47B	47'	Pump	24	10	Rinse water blank
319	7/26/84	CVX-GW-319-60A	60'	Pump	6	18	Rinse water blank
319	7/26/84	CVX-GW-319-60B	60'	Pump	7	23	
320	7/27/84	CVX-GW-320 :27	60'	Pump	23	*	Well installed 7/27/84

*Not detected

GLT441/78-2

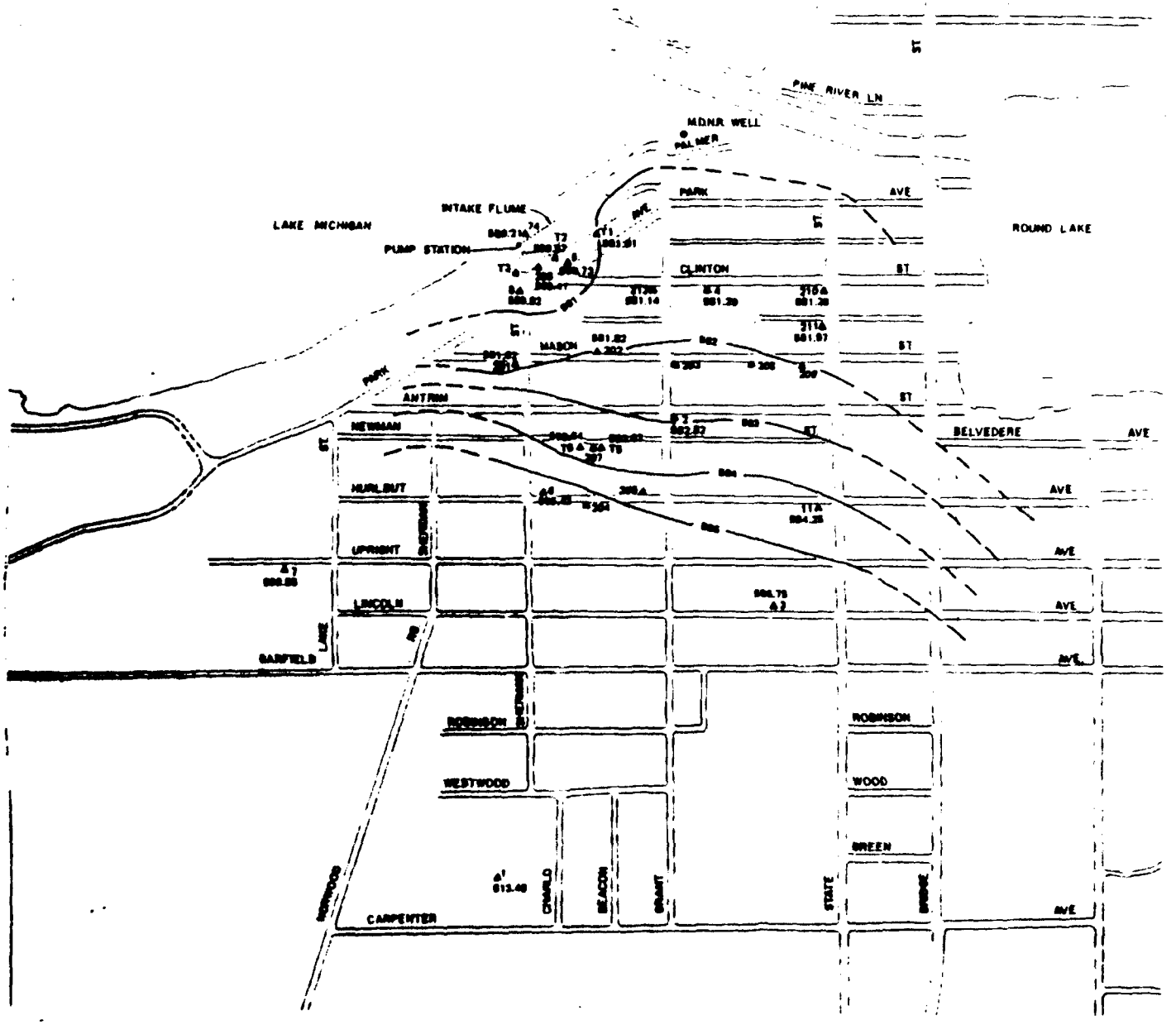
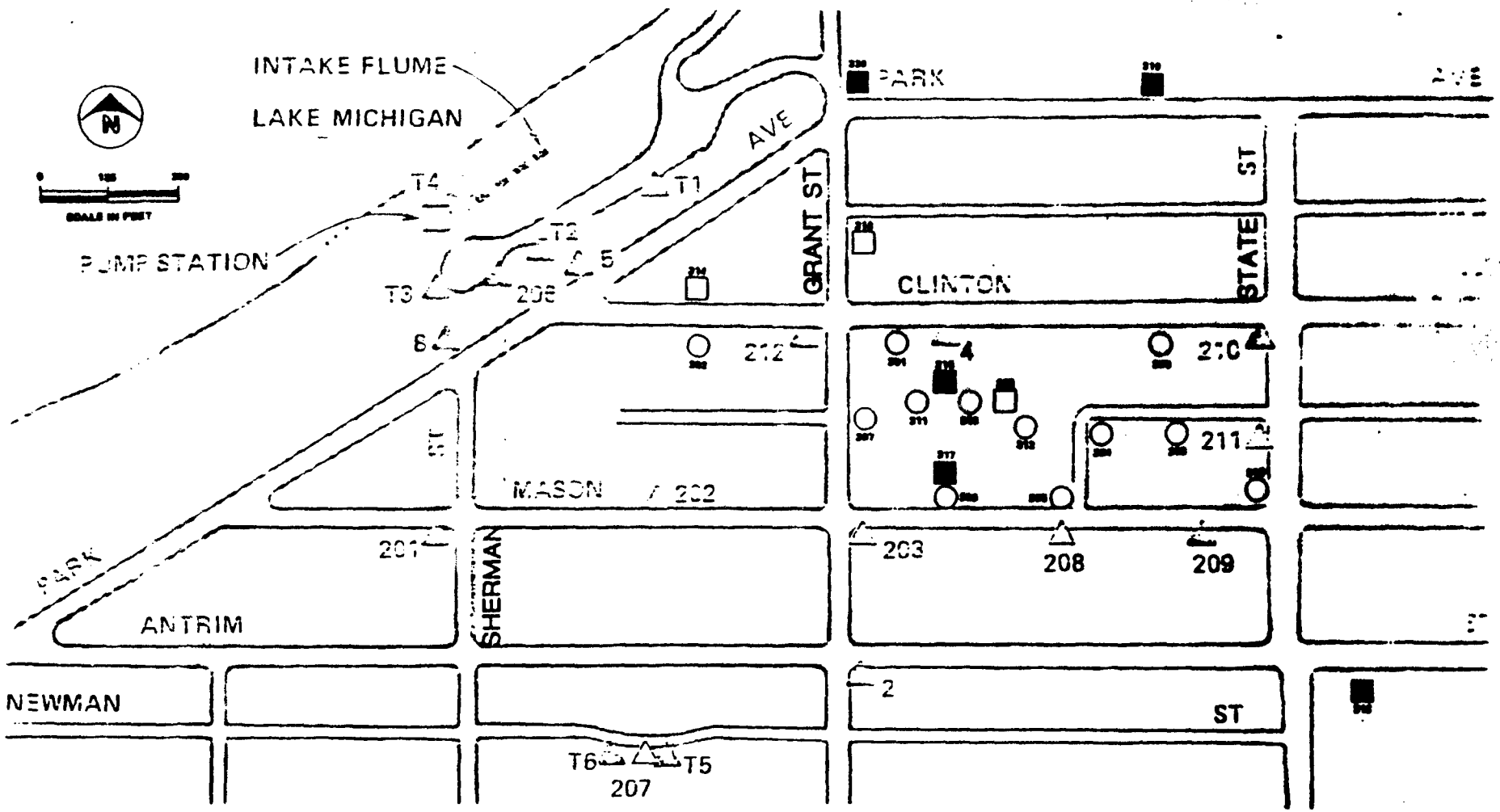


FIGURE 1
EXISTING MONITORING WELL LOCATIONS AND GROUNDWATER CONTOUR MAP
JULY 1994



LEGEND

- ▲ EXISTING MONITORING WELL LOCATION
- △ BORING LOCATION COMPLETED DEC 1983
- ○ ADDITIONAL SHALLOW BORING LOCATION
- □ ADDITIONAL SCREENED HOLLOW STEM AUGER BORING LOCATION
- ■ ADDITIONAL MONITORING WELL LOCATION

FIGURE 2
ADDITIONAL BORING AND MONITORING WELL LOCATIONS

Geotechnical & Materials Consultants, Inc.

FORM-GMC-6-0

LOG OF SOIL BORING NO. B#210

DATE 12/14/83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows For 6"	Recovery %	Natural Wt. P.C.F.	Unit. Comp. Strength PSF.	Qu. %
52'0"			52					
	Wet, fine to medium, brown SAND with traces of silt and fine gravel		53					
			54					
			55					
			56					
			57					
			58					
			59					
			60					
			61					
			62					
			63					
			64					
			65					
			66					
			67					
			68					
69'0"			69					
	Wet, fine to medium, brown SAND with traces of silt		70					
			71					
			72					
			73					
			74					
			75					
			76					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

GMC Associates, Inc.

ENGINEERS • SCIENTISTS • ECONOMISTS • SURVEYORS
[illegible] GERALD, NORTHVILLE, MI 48167 - (313) [illegible]

FORM-GMC-6-0

LOG OF SOIL BORING #
84210
DATE 12/14/83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

76'6"	SOIL DESCRIPTION	Samples & Type	Depth	Penetration Blows for 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Sp. G.
	Wet, fine to medium, brown SAND with traces of silt		77					
			78					
			79					
			80					
			81					
			82					
			83					
			84					
			85					
			86					
			87					
			88					
			89					
			90					
			91					
			92					
93'0"			93					
	END OF BORING		94					
			95					
			96					
			97					
			98					
			99					
			100					
			101					
			102					

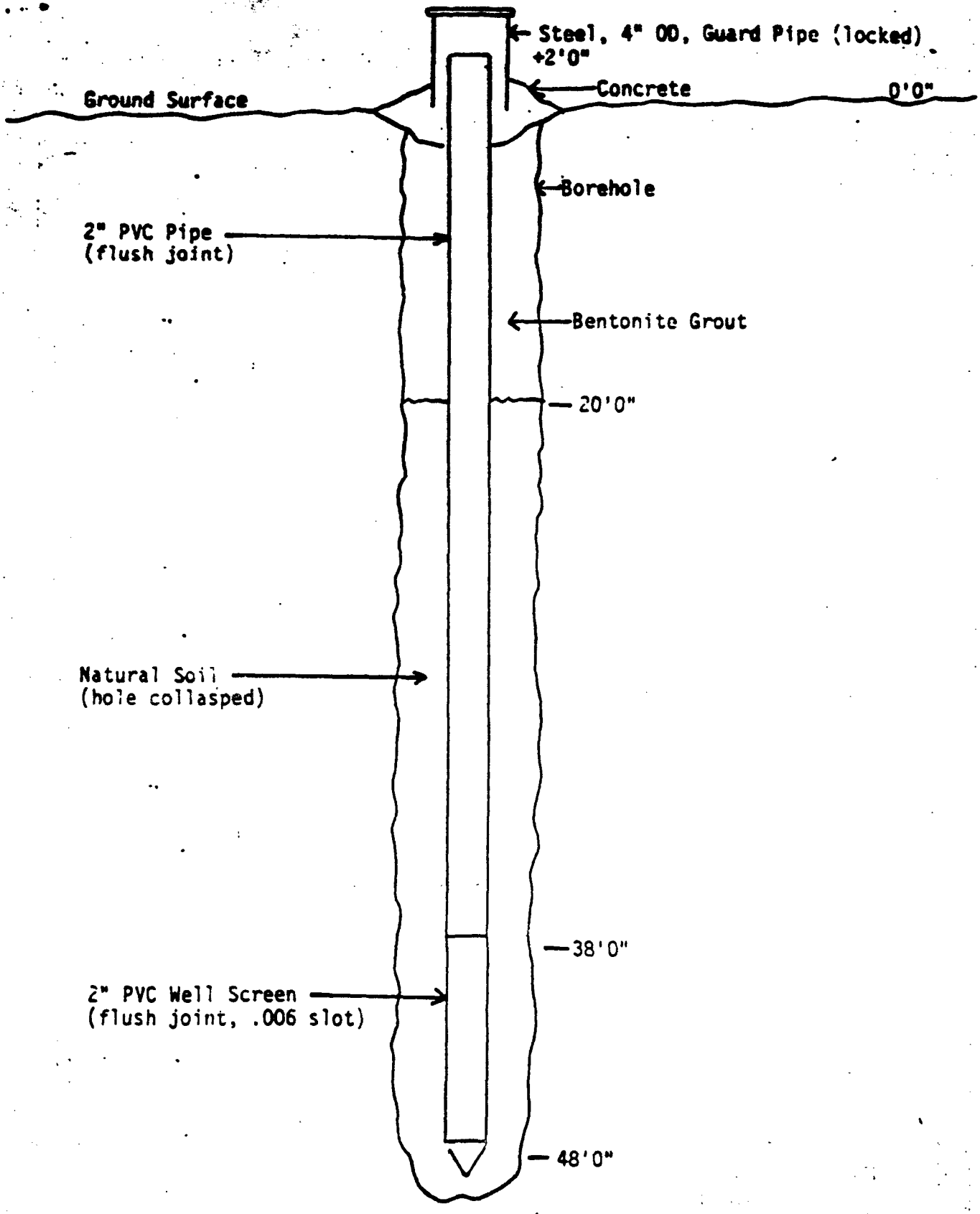
TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140 # Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.



END OF BORING ACTUALLY 93'0"

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19720 GERALD, NORTHVILLE, MI 48167 - (313) 348-4435

B#210 Sketch of Well Installation
Charlevoix Monitoring Wells
GMC Job No. HG-83015
N.T.S.

GMC Associates, Inc.

FORM-GMC-6-0

Page 1 of 4

LOG OF SOIL BORING NO. B#211

DATE 12-15-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt P.C.F.	Unc. Comp. Strength PSF.	Str. %
0'6"	TOPSOIL							
	Moist, fine to medium, dark brown SAND with traces of silt		1					
			2					
			3					
			4					
			5					
6'0"			6					
	Moist, fine, brown SAND with some silt and traces of clay		7					
8'0"			8					
	Moist, fine, brown SAND with little silt		9					
			10					
			11					
			12					
			13					
			14					
			15					
			16					
			17					
			18					
			19					
			20					
			21					
22'0"			22					
	Moist, fine, brown SAND with little silt and fine gravel		23					
			24					
			25					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS: Hole carved from 27' - 87'. Grouted from 27' to the surface.

Standard Penetration Test - Driving 2" OD Sampler 1' With

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT 29' FT. 6" INS.
G.W. AFTER COMPLETION 28' FT. 3" INS.
G.W. AFTER HRS. FT. INS.

GMC Associates, Inc.

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[illegible] GERALD, NORTHVILLE, MI 48167 • (313) 349-4666

FORM-GMC-6-0

LOG OF SOIL BORING NO. B#211

DATE 12-15-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetrating Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Rec. %
27'6"			26					
			27					
	Wet, medium to coarse, brown SAND with some fine gravel and traces of silt.		28					
			29					
			30					
			31					
			32					
			33					
			34					
			35					
			36					
			37					
38'0"			38					
	Wet, medium to coarse, brown SAND with traces of fine gravel and silt.		39					
			40					
			41					
			42					
			43					
			44					
			45					
			46					
			47					
			48					
			49					
			50					
			51					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With [illegible] Rollers 30" Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	FT.	HRS.
G.W. AFTER COMPLETION	FT.	HRS.
G.W. AFTER HRS.	FT.	HRS.

GMC Associates, Inc.

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18720 GERALD, NORTHVILLE, MI 48167 • (313) 348-4000

FORM-GMC-6-0

LOG OF SOIL BORING NO. B#211

DATE 12-15-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Density Wt. P.C.F.	Unc. Comp. Strength PSF.	Rec. %
Wet, medium to coarse, brown SAND with traces of fine gravel and silt		52					
		53					
		54					
		55					
		56					
		57					
		58					
		59					
		60					
		61					
		62					
		63					
		64					
		65					
		66					
		67					
		68					
		69					
		70					
		71					
		72					
		73					
		74					
		75					
		76					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S.-SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.

GMC Associates, Inc.
ENGINEERS • SCIENTISTS • ECONOMISTS • MANAGERS
19728 GERALD, NORTHVILLE, MI 48167 - (313) 348-4155

FORM-GMC-6-0

LOG OF SOIL BORING NO. B#211

DATE 12-15-83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Samples & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	Wet, medium to coarse, brown SAND with traces of fine gravel and silt		77					
			78					
			79					
			80					
			81					
			82					
			83					
			84					
			85					
			86					
87'0"			87					
	END OF BORING		88					
			89					
			90					
			91					
			92					
			93					
			94					
			95					
			96					
			97					
			98					
			99					
			100					
			101					
			102					

TYPE OF SAMPLE
O. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30": Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.

GMC Associates, Inc.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#212

DATE 12-15-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Density lbs P.C.F.	Unc. Comp. Strength PSF.	Str. %
0'6"	TOPSOIL							
	Moist, fine to medium, dark brown SAND with traces of silt		1					
			2					
			3					
4'0"			4					
	Moist, fine to medium, gray SAND with traces of silt		5					
6'0"			6					
	Moist, fine to medium, brown SAND with traces of silt		7					
			8					
			9					
			10					
			11					
			12					
			13					
14'0"			14					
	Moist, medium, light brown SAND with traces of silt		15					
			16					
			17					
			18					
			19					
			20					
			21					
			22					
			23					
			24					
			25					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test – Driving 2" OD Sampler 1' With

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	28'	FT. 5"	INS.
G.W. AFTER COMPLETION	27'	FT. 6"	INS.
G.W. AFTER		FT.	INS.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#212

DATE 12-15-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Graphic & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Dir. %
			26					
			27					
28'0"			28					
	Wet, fine to medium, brown SAND with little silt and fine gravel		29					
			30					
			31					
			32					
			33					
			34					
			35					
			36					
			37					
			38					
			39					
			40					
			41					
42'0"			42					
	Wet, fine to coarse, brown SAND with little fine gravel		43					
			44					
			45					
			46					
			47					
			48					
			49					
			50					
			51					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T. -SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1" With

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	FT.	INS.
G.W. AFTER COMPLETION	FT.	INS.
G.W. AFTER HRS.	FT.	INS.

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FORM-GMC-6-0

LOG OF SOIL BORING NO. B#212

DATE 12-15-83

JOB NO. HG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.	Dry %
Wet, fine to coarse, brown SAND with little fine gravel		52					
		53					
		54					
		55					
		56					
		57					
		58					
		59					
		60					
		61					
		62					
		63					
		64					
		65					
		66					
		67					
		68					
		69					
		70					
		71					
		72					
		73					
		74					
		75					
		76					

TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test - Driving 2" OD S...pler 1' With 140 # Hammer Falling 30": Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	FT.	INS.
G.W. AFTER COMPLETION	FT.	INS.
G.W. AFTER HRS.	FT.	INS.

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FORM-GMC-6-0

LOG OF SOIL BORING #

B#212

DATE 12-15-83

JOB NO. MG-83015 PROJECT Charlevoix - Monitoring Wells SURFACE ELEV.

	SOIL DESCRIPTION	Sample & Type	Depth	Penetration Blows Per 6"	Moisture %	Density WT. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	Wet, fine to coarse, brown SAND with little fine gravel		77					
			78					
			79					
			80					
			81					
			82					
			83					
			84					
			85					
			86					
			87					
88'0"			88					
	END OF BORING		89					
			90					
			91					
			92					
			93					
			94					
			95					
			96					
			97					
			98					
			99					
			100					
			101					
			102					

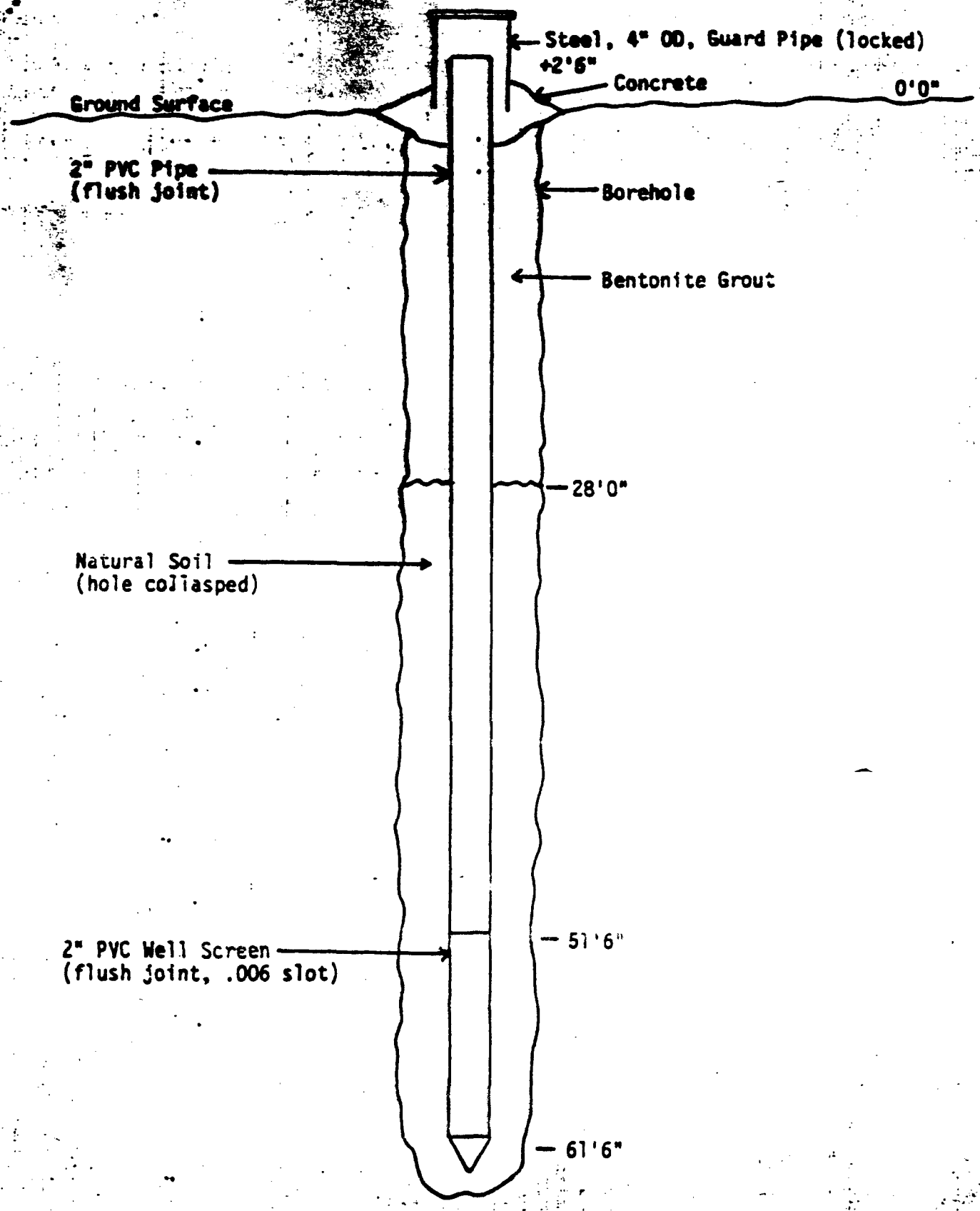
TYPE OF SAMPLE
D. -DISTURBED
U.L.-UNDIST. LINER
S.T.-SHELBY TUBE
S.S. -SPLIT SPOON

REMARKS:

Standard Penetration Test – Driving 2" OD Sampler 1' With 140 # Hammer Falling 30"; Count Made At 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.



END OF BORING ACTUALLY 88'0"

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B#212 Sketch of Well Installation
Charlevoix Monitoring Wells
GMC Job No: HG-83015
N.T.S.